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Continuous Concrete Girder Bridge Offers Interesting Problems

Girders Proportioned to Bending Moments—Ready-Mixed Concrete Supplied in Four Strengths—Support Forms on Falsework—The Concreting Schedule

By **H. D. HILBORN**
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A unique type of continuous reinforced concrete girders, and the use of concrete of four different strengths — supplied by a commercial ready-mixed concrete plant—are among the most interesting features of the McKee Street bridge, recently completed in Houston, Texas.—*The Editors.*

A REINFORCED concrete structure of unusual type and magnitude has recently been completed by the city of Houston. It is a continuous through-girder bridge constructed to carry McKee Street over Buffalo Bayou.

The street makes an angle of approximately 77 deg. with the river channel, which is navigable for small boats above the site of the bridge. The U. S. Army Engineer Department required that a clear opening, having a horizontal width of 100 ft., measured at right angles to the channel, and a vertical height of 42 ft., be provided. To provide for the skew and allow for the wood fender system it was found necessary to provide a 120-ft. span over the channel. Provision for 2:1 bank slopes was made by placing one 85-ft. span, with a cellular type abutment having 40-ft. wing walls, on each end of the channel span.

Consideration of the required opening, first cost, maintenance cost, and finished appearance, governed in the decision as to bridge type. Available headroom dictated that through construction must be adopted.

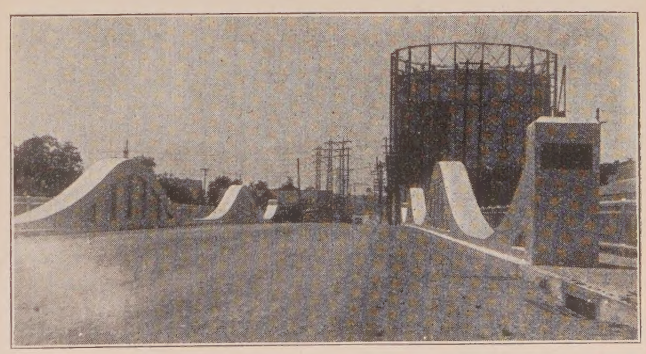
Girders Proportioned to Bending Moments

Girder sections, proportioned as closely as was practicable to the bending moments, resulted in the unusual profile which may be visualized from the illustrations. The girder outline, governed as it was by the bending moments, makes a pleasing appearance. A reverse parabolic curve over the support, with a 20-ft. straight section at midspan, forms the top contour of the girders of the channel span. The bottom rises 3 in., from support to center, in a parabolic curve. A circular arc, with a 5-ft. radius, makes a pleasing sweep connecting the girder soffit with the pier cap. The 60-ft. section of the approach span, adjacent to the pier, is a duplicate of the half channel span. The outer end rises 5 ft., in a parabolic arc, in the remaining 25 ft.

Pier and abutment footings were laid out parallel with the channel. This made a skew of 10 ft. in the distance of 42 ft. 6 in. between girder centers, or one floor beam space. All floor beams except the outer one at each end were framed at right angles to the girders, thereby eliminating many of the objections to skew construction.

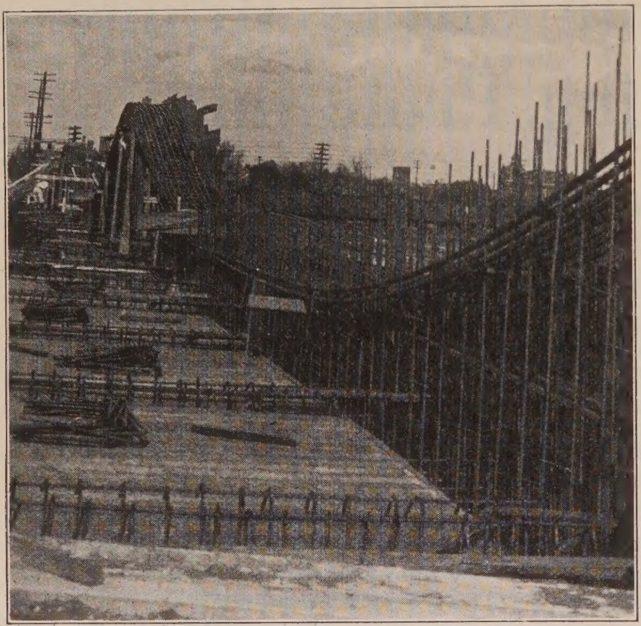
Designed for Standard Live Loads

The roadway is 38 ft. 4 in. wide, face to face of curbs, and accommodates four lines of vehicular traffic. The live loading used in the design provided for one 20-ton truck, preceded and followed by 15-ton trucks, in each traffic lane. Generally the loading was H-20 of the 1929 A. R. E. A. specifications for steel highway bridges. Sidewalks were provided on both sides of the bridge.

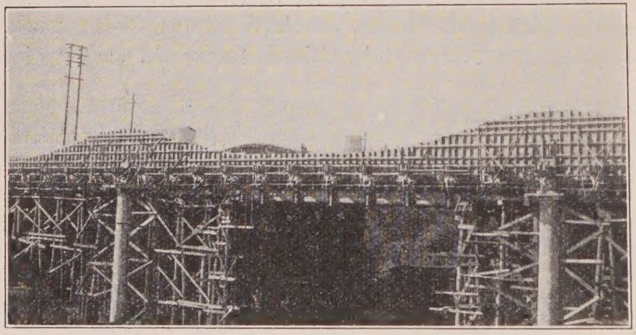

Continuous bridge girders proportioned according to bending moment

In designing the girders, elastic curves were drawn for abutment and pier reactions. Shearing stresses were investigated and moments figured at all floor beam points. To facilitate the moment calculations, moment curves were prepared for those conditions of loading which would produce maximum moments in the outer span, in the center span and over the supports, as well as for dead loads only.

Because of the variation in girder section, moments of inertia were figured at all points used in preparing influence diagrams—namely, at 5-ft. intervals. Reinforcing steel was ignored in figuring relative stiffness, the calculations being based on the actual concrete dimensions.


Girder reinforcement placed before form work was erected

The floor slab was reinforced in both directions and was figured accordingly. Stringers 10 by 24 in. in size and on 10-ft. centers serve to relieve the floor beams through distribution of any excessive concentrations coming upon them, and, together with the floor beams, divide the slab into square panels.


Girder forms supported on falsework

Heavy girders, 18 by 72 in., over the piers, complete the rigid frames which make up the bents.

It was desired to relieve the girders so far as possible, of restraint at supports. This was fully assured at the abutments by the use of roller bearings under each girder. The piers were designed for maximum flexibility. With a shaft height of 39.5 ft. the base width is only 4 ft. Steel, anchoring the girders to the piers, was placed in two rows only 12 in. apart, thus approximating a hinged condition. The girders were built out over the bearings by means of pilasters, to reduce bearing stresses. Spirals were placed in the pier tops and in the girder columns to take care of possible eccentricity in the transfer of the girder reaction to the pier.

Pile Foundations

Wood foundation piles 50 ft. long, under the piers, were driven 30 ft. into clay. No reliance was placed on the overlying sand, since it may scour under flood conditions. Driving of these long piles was difficult and required special jetting equipment.

The abutments are supported by 25-ft. precast concrete piles, 14 by 14 in. in section.

Transit-Mixed Concrete of Four Different Strengths

All concrete materials were proportioned by careful weighing and mixed in transit. In mixing the 2,000-lb. concrete used in the pier bases, the maximum water-cement ratio permitted was 7¼ gal. per sack of cement; in the 2,500-lb. concrete, used in abutments, pier shafts and sidewalks, the maximum water-cement ratio was 6½ gal. per sack; in the 3,000-lb. concrete, used in the piles, the maximum water-cement ratio was 5¾ gal. per sack. The 4,000-lb. concrete, used in the girders and floor system, was mixed in the proportions of 94:160:282, dry mix, with a water-cement ratio of 4¾ gal. per sack. Cylinder tests of the 4,000-lb. concrete showed 28-day strengths varying from 3,700 to 4,800 lb. per sq. in. For this class of concrete the maximum size of aggregate was 1 in. and the slump from 6 to 8 in.

In the design, the compressive stress in the girders, under full live load, was limited to approximately 1,100 lb. per sq. in. Special attention was given to shearing stresses.

The Girder Reinforcement

Flexure reinforcement in the girders was arranged in the form of 4 layers of 1¼-in. square rods in the 120-ft. span, and 5 layers in the 85-ft. span, to take care of positive moments. Over the supports, 7 layers of 1¼-in. square rods were necessary to provide for negative moments. The rods were spaced to allow ample bond. Vertical stirrups, ⅝ and ¾-in. round rods, were provided near midspan, with 1⅛-in. square inclined stirrups where shears were high.

To insure proper placing of the heavy tension and shear reinforcement over the piers and to provide for a thorough inspection of it after it had been secured in place, the specifications required that this steel be placed before girder side forms were erected. The 1¼-in. rods were supported by hangers.

Forms Supported on Falsework

To preclude the possibility of dangerous settlement or deflections during concreting, or before the concrete had properly cured, a falsework plan for supporting forms was furnished with the bid plans. Requirements of the U. S. Army Engineers, for the construction period, permitted of reducing the channel opening to a 60-ft. horizontal clearance, measured at right angles to the channel, with a clear height of 30 ft. above mean low water. A 66-ft. span, measured from center to center of supports, was thus necessary, and 36-in. I-beams were specified for this opening.

Concreting Schedule on Superstructure

Concreting of the superstructure was divided into five sections, of which the first two were centered over the piers, the third and fourth were adjacent to the abutments, and the fifth was the middle third of the center span. This was not only of advantage to the contractor; it was desirable from an engineering standpoint in that it reduced shrinkage stresses to a minimum. The slope of the construction joints made compression in the bearings certain. In addition to the reinforcing provided to satisfy design stresses, 16 rods 1¼ in. square were placed, on an incline, through each joint.

Material Quantities

Out-to-out of abutments, the bridge measures 370 ft., and out-to-out of sidewalk brackets, 57 ft. Some of the quantities were 2,250 cu. yd. of concrete, 75,000 sq. ft. of form surface, and 314 tons of reinforcing rods. Of this concrete volume, 920 cu. yd. was of 4,000-lb. strength. The contract price, which included removal of the old swing bridge and its foundations, was $122,000.

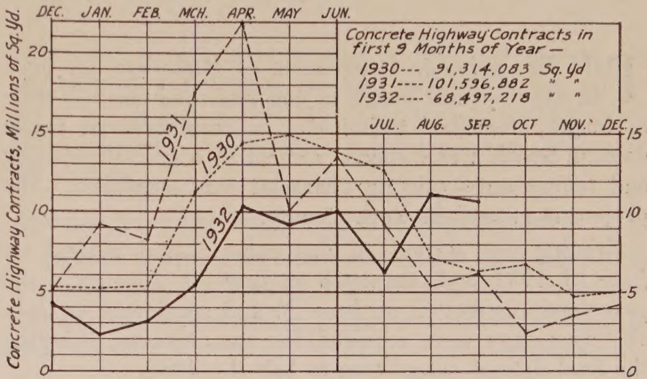
J. M. Nagle, city engineer, exercised general direction over the work. J. G. McKenzie, bridge engineer, personally supervised the design and construction of the project. L. C. Wagner and the writer acted as principal assistants in the design and preparation of plans. Don Hall, Constructor, Inc., of Houston, was general contractor. All concrete was delivered ready mixed, in the forms, by a local ready-mixed concrete plant that employs the transit mixer method.

Contracts for Concrete Highways Continue at High Level

Highway Departments Stimulate Construction—September Is Second Largest Month

Contracts awarded throughout the United States during the month of September for concrete highway construction amounted to 10,690,223 sq. yd., only slightly under the August contracts for 11,136,778 sq. yd., according to the figures compiled by the Portland Cement Association.

The September contracts, as the chart indicates, are more than 4 million square yards in excess of the same month of 1930 and 1931, and are the second largest monthly awards in 1932. The monthly average for the first 9 months of 1932 is 7,610,802 sq. yd.



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Contracts for the first 9 months of 1932 stand at 67.4 per cent of the corresponding period of 1931, while on July 1 the total was only 50 per cent of the first 6 months of last year.

One-Family and Two-Family Dwellings Built in Five-Year Period

Manufacturers of concrete wall units and concrete roofing tile, contractors who specialize in concrete foundations or in stucco work, and others concerned with the use of some form of concrete units or monolithic concrete in dwelling house construction, will be interested in a summary of the number of one-family and two-family dwellings built annually in various sections of the United States.

Such a summary is given in the accompanying tabulation, for which CONCRETE is indebted to the statistical research service of the F. W. Dodge Corporation.

CONTRACTS AWARDED FOR ONE-FAMILY AND TWO-FAMILY HOUSE CONSTRUCTION IN 37 STATES

District	1927	1928	1929	1930	1931
New England States	14,518	18,302	13,455	10,311	9,761
N. Y. and No. N. J.	26,468	30,059	19,158	17,628	21,847
Middle Atlantic States	28,664	30,125	20,161	10,792	9,322
Southeastern States	21,491	20,990	16,277	8,422	8,189
Pittsburgh Territory	20,259	18,253	15,317	10,138	7,367
Central West	39,075	53,418	44,826	24,580	16,532
Northwest	3,988	3,195	2,148	1,879	2,261
Texas	11,513	11,105	9,239	5,495	4,180
TOTALS	165,976	185,447	140,581	89,245	79,459

It is well to observe that this tabulation includes years of high volume of dwelling house construction as well as the years of low volume.

Districts Embraced

The district here designated as Middle Atlantic States includes Maryland, Virginia, Delaware, the District of Columbia, the eastern half of Pennsylvania and the southern half of New Jersey.

The Southeastern States district includes North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, Mississippi, Louisiana and Arkansas.

Pittsburgh Territory comprises Ohio, West Virginia, Kentucky and the western half of Pennsylvania.

The Central West district includes Indiana, Michigan (except the northern peninsula), Illinois, Wisconsin, Iowa, Nebraska, Missouri, Kansas and Oklahoma.

The Northwest district includes Minnesota, North Dakota, South Dakota, and the northern peninsula of Michigan.

The states included in the first two and in the last of the eight districts are indicated by the names of the districts.

Experimental Road Opened in Twelve Hours

Pennsylvania Highway Department Tries New Special Cement — Is Quick-Hardening and Temperature-Resistant — The Construction Procedure

By U. J. ECKMAN
District Superintendent, Pennsylvania Department of Highways, Harrisburg, Pa.

THE Pennsylvania Department of Highways has built an experimental stretch of concrete road one-half mile in length, described technically as cement-bound macadam, in which a new special cement of a quick-hardening and temperature-resisting character was employed. The project is located in York County.

Grading was started on this experimental project on June 15, 1932, and completed on June 29. Placing of the pavement was started on June 30 and completed on July 12. Two days were required for the clean-up, bringing the final date of completion to July 14, 1932.

Ten working days were required to place the pavement, which is 2,618 ft. long, 18 ft. wide, and is compacted to a thickness of 4 in. on a pre-paved subgrade. Due to the additional pavement area on curves and elsewhere, the total area of the project is 5,518 sq. yd., so that the average rate of placing was 552 sq. yd. per day.

The Working Procedure

The following procedure was used in placing the pavement throughout the project. Steel forms were used and were kept 300 ft. ahead of the mixers at all times. The materials were spread proportionately along the sides of the subgrade, and the paver (27E) moved along the center of the subgrade, mixing the heavy mortar, which was of a plaster consistency containing three parts of sand to one part of special cement. The mortar was of a moderate stiffness. This heavy mortar was uniformly spread to a depth of 2 in. on the pre-paved subgrade. On this mortar, a layer of broken stone (Pa. No. 4) was spread with forks, this layer being approximately 5 in. thick, while loose.

This loose course of stone was then pressed firmly into the bed of mortar to a total thickness of 4 in. with a 10-ton steam roller, care being exercised so that the whole stone course lay firm and stable under the roller. Where the stones moved, additional stones were spread in front of the roller so that the course became perfectly keyed and immovable. To avoid pushing of stones, no walking was allowed over the course of stone, but where walking was unavoidable, it was done on boards placed flat over the stones.

After the stone course had been sufficiently rolled and the mortar had worked through to the surface, a thin course of chips (Pa. No. 1A) was spread. This was pressed down by the roller, thus completing the keying. Over this thin covering of chips another layer of mortar was spread. This top mortar was mixed in a smaller mixer (14S) and followed in the path of the large mixer. This top mortar was mixed to a thinner consistency, and it contained two parts of sand to one part of special cement. This light, watery top mortar was brushed uniformly into the stone, leaving a mosaic effect on the surface.

Brushing was then done carefully to avoid the loosening of any stones. After this upper mortar was uniformly brushed, it was rolled with a 5-ton roller, the wheels of which were kept damp to avoid picking up the grout. It was very important that the heavy roller did not touch a finished section. To avoid this possibility a bulkhead was placed at the end of each section, beyond which the heavy roller did not move.

As work advanced during the day, the bulkheads were removed and the space left by them was filled with mortar and stone, which was worked in vigorously by hand tamping. Care was taken so that the top mortar layer was not too deep, as it must be just flush over all the stone tops and must merely be covered with a mortar brushing, leaving a semi-rough surface.

Opened to Traffic in 12 Hours

Traffic was allowed to pass over the finished sections 12 hours after the pavement was placed.

Total materials used on this project included 807 tons of No. 4 stone, 17 tons of No. 1A chips, 538 tons of sand, and 858 bbl. of cement.

The project was built in co-operation with the Medusa Portland Cement Co. The cement is a special product described as a temperature-resisting cement, developed in Germany. It is being manufactured at three of the Medusa plants, namely, at York, Pa., at Silica, Ohio, and at Manitowoc, Wis.

Concrete Ashlar and Cement Paint at World's Fair

Concrete ashlar work and the color effects of cement paint will be on display in a very practical form before millions of visitors to Chicago's Century of Progress Exposition in 1933.

This display will appear in the building now being built by the General Motors Corporation. The attractive texture and color scheme will be in accordance with the specifications of Albert Kahn, the well-known Detroit architect, who will employ 20,000 concrete ashlar units, with cement paint, in the interior of the auditorium of this building.

Logical Use of Calcium Chloride in Pavement Concrete

Effect of Temperature on Early Strength — Both Quick-Hardening and Standard Portland Cements Investigated, With and Without $CaCl_2$

By **H. F. CLEMMER**
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HIGHWAY engineers as well as engineers in charge of city paving work will be interested in the following results and conclusions from a study of the effect of varying temperatures on both high-early-strength cements and standard portland cements, both with and without calcium chloride incorporated in the concrete mix, carried on in the highway department laboratory of the District of Columbia.

A summary of the results of these tests leads to the following recommendations (the prices quoted for high-early-strength cement in the District of Columbia are at present but little more than for standard cement, which fact enters into consideration):

(1) At 70 deg. F. or above, the use of high-early-strength cement without calcium chloride.

(2) 60 deg. F. or below, the use of high-early-strength cement with 1½ per cent of calcium chloride.

(3) For pavement concrete (to obtain same appearance—

(a) 70 deg. F. or above, standard portland cement with 1½ per cent of calcium chloride.

(b) 60 deg. F. or below, standard portland cement increased from 1.6 to approximately 1.8 bbl. per cu. yd., with 1½ per cent of calcium chloride.

Purpose and Scope of Tests

From the study of field tests of concrete made by the Highway Department, Division of Materials, of the District of Columbia, during 1931 as a check on the quality of the concrete for the purpose of determining when sufficient strength has developed in the concrete to permit opening of the pavement to traffic, the effect of varying temperatures on both high-early-strength and standard portland cement concrete was found to be most important. An investigation was made to determine the best means of obtaining early-strength concrete at various temperatures. Tests were made on several brands of both high-early-strength and standard portland cements, with and without calcium chloride incorporated in the mix. It was thought that standard cement with calcium chloride as an accelerator might prove as satisfactory and more economical than the use of high-early-strength cement. It was also of interest to determine the value of calcium chloride with high-early-strength cement in overcoming the effect of low temperatures during setting of the concrete. The four different mixes were subjected to varying temperatures, as might be encountered in construction work. Some knowledge of the behavior of these different mixes at various temperatures is necessary for the engineer to specify either a high-early-strength or standard cement, with or without admixtures, in any particular case and to know which mix is best, why it is best, and the approximate strengths to expect from the particular mix at the early ages.

Special Uses for High-Early-Strength Cement

High-early-strength cement concrete is particularly recommended at intersections and for the base construction of bituminous pavements. In the construction work of the highway department of the District of Columbia, it is most important to obtain early-strength concrete, particularly under these conditions, so as not to cause undue congestion of traffic. The department therefore uses a considerable quantity of high-early-strength cement.

One particular project in which considerable high-early-strength cement was used was a concrete base on an important thoroughfare. Construction was started early in the spring when temperatures were quite low. The early-strengths obtained were very low, and it was the interest in this project that particularly drew the attention of the department to the problem.

Five Brands of Cement

This article endeavors to present the data obtained in as practical a manner as possible so as to be of use to engineers engaged in highway construction work.

Three brands of high-early-strength cement and two brands of standard portland cement were used for this investigation. The results of tests for each brand at various temperature conditions were plotted. The individual curves did not vary to any great extent from the average summary curves, so it may be stated that any irregular phenomena in the average were not produced by varying test results from any one cement.

Proportions Employed

The mix used for the major part of this investigation was 1:2:3½, by weight, with 6 gal. of water per bag of cement, which produced a concrete with an average flow of 130 and an average slump of 2 in. When calcium chloride was used it was added at the rate of 1½ per cent for temperatures up to 70 deg. F., and 1 per cent for temperatures above 70 deg. F.

The results of tests on 9 cylinders of three different batches were averaged to obtain the numerical abscissa for each point plotted on the charts.

Concrete made with high-early-strength cement was compared with concrete made with standard portland cement, both with and without calcium chloride incorporated in the mix, at varying temperatures of 70 deg. F., 50 deg. F., 40 deg. F., 40 deg. F. rising to 60 deg. F., 40 deg. F. falling to 20 deg. F., 60 deg. F. rising to 70 deg. F., and 60 deg. F. falling to 40 deg. F. These cycles, in the cases of rising and falling temperatures, required 24 hours for completion, 12 hours falling to the stated temperature and 12 hours rising to the original temperature; seven complete cycles were used in each case.

Laboratory Facilities

The design of the laboratory contains three air conditioned rooms which afford an opportunity for studying concrete under varying conditions, as well as standard conditions for the making, curing, and testing of concrete specimens.

The moist room is kept at 70 deg. F. and 100 per cent relative humidity. In this room cylinders for compression tests, briquettes, pats, and all test specimens are stored for proper curing. In conjunction with the moist room, there is a constant-temperature room and a cold room. The constant-temperature room is kept at 70 deg. F. for making all test specimens of cement, mortar, and concrete used by the District of Columbia in construction work or for research projects. The cold room can be regulated to maintain any temperature between plus 70 deg. F. and minus 25 deg. F. Freezing and thawing tests to determine the durability of aggregate or concrete are performed in this room, as well as experimental research on curing of concrete at varying temperatures.

The results of tests at 70 deg. F. show that standard portland cement concrete with 1½ per cent of calcium chloride and high-early-strength cement concrete without calcium chloride follow generally the same strength-age plot, and when this condition of temperature is encountered, the question of which to use is a question of economy as to the cost of the materials.

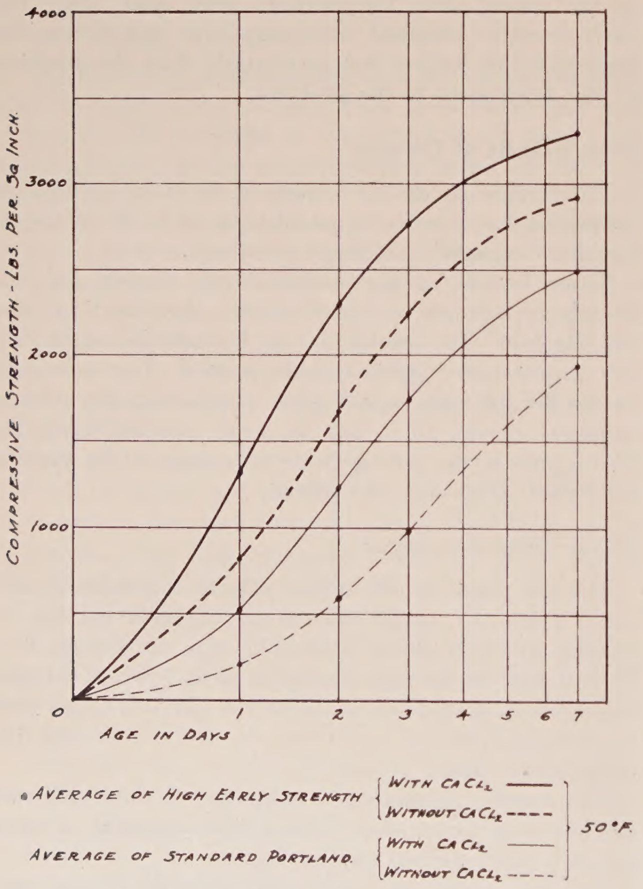

Figure 1. High-early-strength cement and calcium chloride obtain maximum strength in shortest time

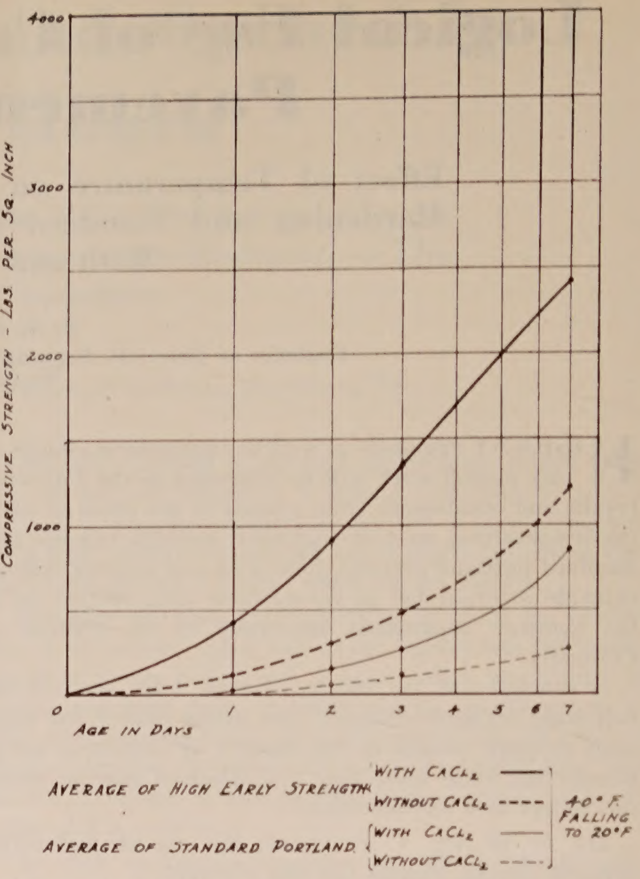

Figure 2. Showing advantages of high-early-strength cement with calcium chloride in low-temperature weather

Maximum Strength in Shortest Time

The results of tests, as plotted in Figure 1, comparing the strengths of concrete at 50 deg. F., show a regular increase in strength. The high-early-strength cement concrete and the standard portland cement concrete, both with and without calcium chloride, follow definite increases in strength. The results show the value of using high-early-strength cement and calcium chloride to obtain maximum strength in the shortest time.

Other tests show definitely that at 40 deg. F. the question as to cements is one of economy between high-early-strength cement concrete without calcium chloride and standard portland cement concrete with 1½ per cent calcium chloride. High-early-strength cement concrete plus 1½ per cent calcium chloride shows a rapid normal increase in strength up to 7 days, and indicates the advantage of this mixture.

At a temperature of 40 deg. F., rising to 60 deg. F., and dropping back to 40 deg. F. in 24 hours, the high-early-strength cement concrete without calcium chloride and the standard portland cement concrete plus 1½ per cent calcium chloride increase in strength at the same rate, so that the only advantage is one of economy as to which one will be the cheaper. High-early-strength cement concrete plus 1½ per cent calcium chloride gains a strength of 2,000 lb. per sq. in. in 32 hours and continues to gain rapidly from this point. These results show the advantage of high-early-strength cement concrete with 1½ per cent calcium chloride in low-temperature weather.

Where Calcium Chloride Reaches Greatest Value

The results of the tests plotted in Figure 2 show to a greater extent the advantage of using high-early-strength cement concrete in low-temperature weather. Where it is important to obtain high-early-strength concrete within 24 or at least 48 hours, the resultant low strengths of standard portland cement with or without calcium chloride and high-early-strength cement concrete without calcium chloride show clearly the inadvisability of using standard portland cements or high-early-strength cement without calcium chloride during relatively cold weather (40 deg. F., falling to 20 deg. F.).

One group of tests brought out the advantage of economy in using standard portland cement concrete with 1½ per cent of calcium chloride to get high-strength concrete in 24 hours, when relatively high temperatures are encountered during the summer months. The strengths of the high-early-strength cement concrete without calcium chloride and the standard portland cement concrete with 1½ per cent calcium chloride increase simultaneously, so that a choice between the two would be decided upon a cost basis. The high-early-strength cement concrete with 1½ per cent calcium chloride increases in strength very rapidly for 24 hours, from which time its increase in strength is more gradual. This is another indication of the advantage of high-early-strength cement concrete with 1½ per cent calcium chloride where it is imperative that high strength be obtained in one day.

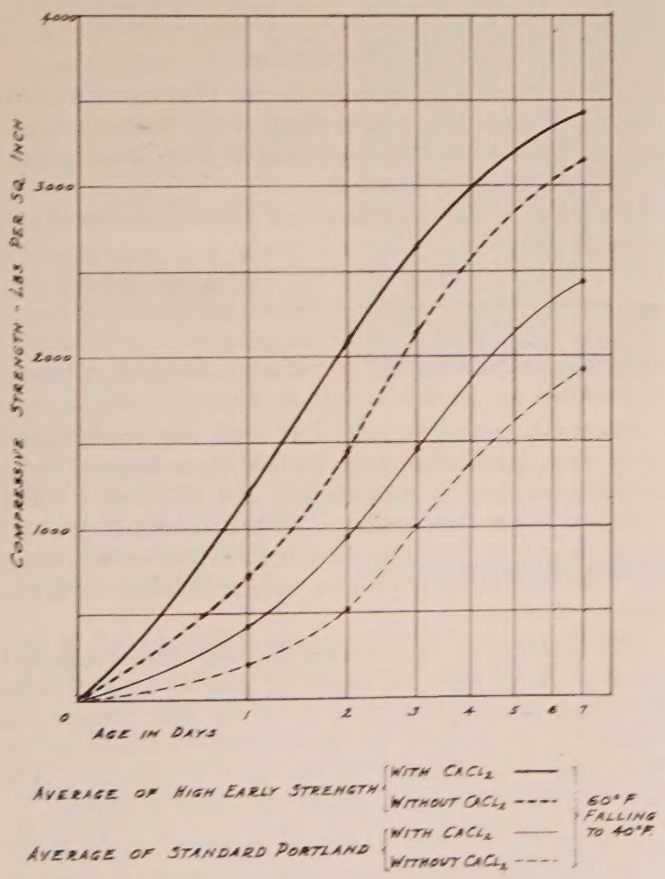

Figure 3. Where use of calcium chloride with standard portland cement becomes imperative

Line of Demarcation

The tests plotted in Figure 3 show distinctly the line of demarcation where the advantage of using high-early-strength cement concrete is shown and the advantage of using standard portland cement with calcium chloride.

For pavement concrete it is desirable that the same appearance as to shade of color be maintained. It is therefore of interest to consider the use of an increased amount of the same brand of cement when a high-early-strength concrete is desired. A change to a high-early-strength cement may produce a color of concrete different from that used on the previous construction.

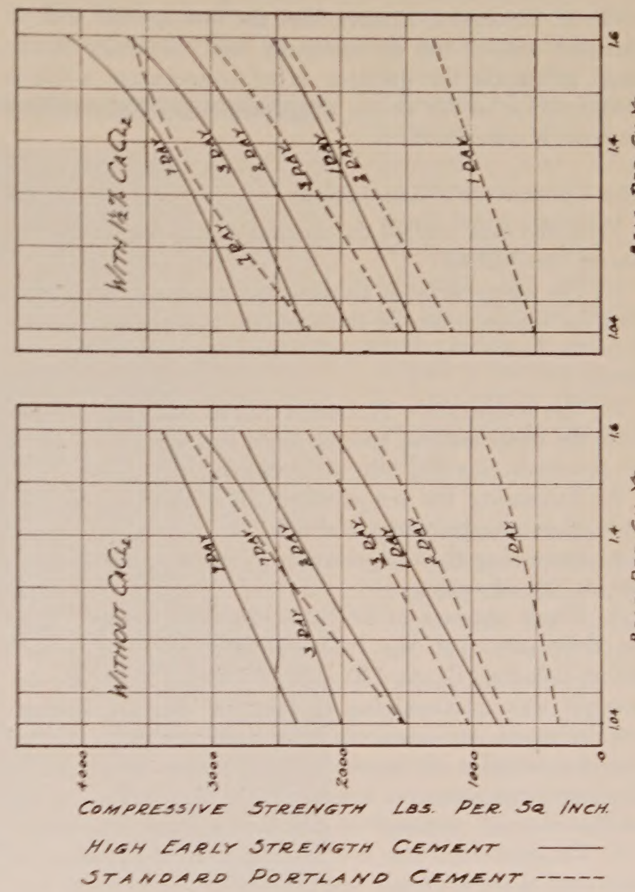

Figure 4. Early-strength effects of calcium chloride

Hot Cement Not Detrimental to Concrete

A. S. T. M. Committee Finds Hot Cement Only Minor Factor in Temperature of Resulting Concrete

The effect of hot cement on the strength, rate of hardening and other properties of concrete has been under investigation by Section IV of Committee C-1 on Cement, of the American Society for Testing Materials. The report and conclusions resulting from the investigation appear in the main report of Committee C-1, presented at the 1932 annual meeting of the society.

Because of the practice, in some cases, of delivering fresh cement direct from the mills for use in concrete highway construction, some highway engineers have raised the question of whether cement having a high temperature at the time of use affects the properties of the resulting concrete. Several state highway departments have established maximum allowable temperatures for cement.

Temperature of Cement Is Minor Factor

The committee's conclusions emphasize a point that has been stressed in several articles published in former issues of CONCRETE, namely, that the low specific heat of portland cement and its relatively small quantity in the usual mix make the question of its temperature a minor consideration so far as the temperature of freshly mixed concrete is concerned.

The Committee's Conclusions

From the data studied the committee has drawn the following conclusions:

1. The temperature of the freshly mixed concrete rather than the temperatures of the separate ingredients appears to be the factor which influences the properties of the concrete.
2. The temperature of freshly mixed concrete depends upon the temperatures, specific heats and weights of all of the materials entering into the concrete.
3. Increasing the temperature of freshly mixed concrete decreases the slump and flow.
4. Increasing the temperature of cement paste accelerates its rate of setting.
5. There appears to be little effect on strength until the temperature of the freshly mixed concrete is well above 100 deg. F. At 130 and 165 deg. F. the one-day strength was increased but at later periods the strength was decreased; the compressive strength was more affected than the modulus of rupture. The decrease in strength at the higher temperatures appears to be due in part to the additional water required to maintain a given consistency.
6. On account of the low specific heat of portland cement and of its relatively small quantity in the usual mix, the temperature at the time of use of portland cement of normal properties appears to be a minor factor in producing high temperatures of freshly mixed concrete under usual job conditions.
7. The temperature at the time of use of portland cement of normal properties was unimportant under job conditions covered by this report.

Continue Efforts for Unemployed Technical Men

Sponsored by the Engineers' Club of Philadelphia, the Philadelphia Technical Service Committee is continuing its efforts toward placing unemployed engineers and chemists in touch with industrial executives and other prospective employers.

Organized as a co-operative effort by unemployed engineers to conduct an efficient placement service, the committee has at the same time assembled for the executive a file of technical men of every grade in the engineering and chemical professions. Thus the employer can be put in touch with the technical men who can make his product more salable, increase plant efficiency, and create new products required by the consumer. These two services are offered without charge to the individuals using it. A third service consists of compiling original data pertinent to Philadelphia's requirements for technical personnel, and the effects of industrial retrenchment on their welfare. This work is co-ordinated with that of the state employment commission, as are also the employment activities, thus avoiding duplication.

Highway Research Board Meets in December

The twelfth annual meeting of the Highway Research Board will convene in the building of the National Academy of Sciences at 2101 Constitution Ave., Washington, D. C., on December 1 and 2.

A number of papers by qualified highway engineers are to be presented.

Temporary Steam Curing Proves Economical

By MILES N. CLAIR

Vice-President, The Thompson & Lichtner Co., Inc., Boston, Mass.

The present business conditions allow the least capital expenditure and yet require the minimum of production costs. The Madestone Products Associates, of Boston, Mass., met these requirements during the late spring of this year when faced with the necessity of completing a contract for their units in approximately half the usual time. Steam curing was necessary in order to reduce the time required before stripping; but no steaming chambers were available and the time and money to build them were lacking. Hoods were made, therefore, of Sisalkraft, an asphalt-combined and sisal-reinforced waterproof kraft paper, to be placed over the molds in which the Madestone units are cast. Steam was introduced under the hoods for eight hours and then the forms were stripped, cleaned, and refilled for another run of units.

The hoods were 8 ft. long, 2 ft. wide and 2½ ft. deep. They were used twice daily for ten days, exposed to a temperature ranging between 160 and 212 deg. F., and remained in excellent condition. A hood of Sisalkraft 3 ft. square and 1 ft. deep was used as an experimental steaming chamber for 65 steamings, each of 2 hours duration, without damage.

The operation of the plant for the rush contract required the removal of material, ready for another project, from the plant to the plant yard or to the job. Cheap and efficient protection for the fine finished surfaces of the Madestone was obtained by the use of Sisalkraft as a covering material to supplement the canvas available.

Charles G. Sherman is general manager of the Madestone Products Associates and The Thompson & Lichtner Co., Inc., were the consulting engineers in this successful curing method.

Elbert Edgar Haight

(1879 - 1932)

ELBERT E. HAIGHT, president and business manager of the Concrete Publishing Company, passed away at St. Francis Hospital in Evanston, Illinois, on October 15, following an illness of two months. Complications resulting from pneumonia were responsible for his untimely end.

Mr. Haight was widely known in business paper circles, having been western manager of the Class Journal Company for 18 years prior to 1925. For a number of years he served on the executive committee of the Associated Business Papers, Inc., and he was at all times a firm believer in the aims and purposes of that organization.

In 1925 he organized his own company, the Concrete Publishing Company, publishers of "Concrete" and the Cement Mill Edition of "Concrete," which up to that time had been published in Detroit.

In the passing of Mr. Haight the publishing fraternity has lost a man who had unbounded faith in the business paper as a constructive force; his business associates have lost an advisor who always kept his feet on the ground, and his family has lost a devoted husband and father.

E. E. Haight

MR. HAIGHT conducted his business affairs on a basis of fair dealing to all, for that is the only basis upon which a man of his sterling character can operate a business. He had little patience with pretense or outward display, preferring knowledge and facts instead. In the collection of knowledge and facts he was interested in the viewpoint of the foreman or the workman on the job as much as in the opinion of the executive, for he realized that much could be learned from both sources. While he was a man of few words himself, his sincerity and quiet personality seldom failed to win the confidence of those whom he engaged in conversation.

His high standing, both as a man and as a business associate, was due in no small measure to his unwavering loyalty to the interests of the organization of which he formed a part. Thoroughness and hard work were foremost in his business creed. He centered his attention on the essential things, and with it all he mixed a humanity and a sincerity that endeared him to his associates.

ONE of his most lovable characteristics was his devotion to his home and his family, and his love of young people in general. He was a public-spirited citizen, and gave much of his time and energy to local affairs of public interest in the community of Glencoe, Illinois, where he lived. He was a member of Glencoe Lodge, A. F. & A. M., and an alumnus of the University of Michigan, from which he graduated in 1900.

Mr. Haight passed his fifty-third birthday anniversary on October 2. He is survived by his widow, Mrs. Zuella Love Haight, and two children, Virginia L. and Elbert Edgar Haight, Jr., of 815 Bluff St., Glencoe, Illinois. Other surviving members of the family are his mother, Mrs. Edgar Haight; his grandmother, Mrs. M. D. Ashpole, and his two sisters, Mrs. J. M. Love and Mrs. Bess Harney, all living in Sycamore, Illinois, the original family home of several generations.

He was laid to rest in Elmwood Cemetery, in Sycamore, on October 17, following a short service at the home in Glencoe.

Starting R. F. C. Construction Work in Smaller Communities

Need for Prompt Action Emphasized—A Few Examples of Loans Being Granted—Helping Local Officials

THE new Federal Relief and Construction Act is well under way. The newest development in the program is the emphasis placed on the importance of getting local building work started immediately.

This program is intended primarily to spur local construction of needed improvements, with relief of local unemployment conditions, use of local materials and general benefit to local business. It is necessary to overcome the erroneous idea that the vast sum now available for relief, work relief and local construction is intended primarily for federal use, or for the use of large corporations. Some of the money will be used for these purposes, but by far the greatest amount is intended for the individual community—to towns, cities, counties and states throughout the country—for immediate use for relief and on local construction work as the local governmental bodies see fit.

Largest Fund for Local Projects

There is available under the Relief Act a total of $2,122,000,000. Of this total some $200,000,000 goes directly into federal works already authorized. Some additional funds will be loaned to states for federal-aid highway work and there will be loans for forest preservation, agricultural relief and marketing and certain other projects. But the major part of the two billion dollars remaining, many times the amount scheduled for any other activity, is to be devoted entirely to local construction and relief work, as planned, directed and worked out by local agencies.

Many Requests for Loans

Loan requests from every part of the country are now pouring into Washington. Almost every type of local improvement is being considered under one or another section of the Relief Act. Under section I of the Act, which provides $300,000,000 for relief and work relief for local communities, many towns, cities and counties, as well as states, are applying for funds to be used for suitable local projects as well as for direct relief.

To provide work for the local unemployed, requests for funds for the construction of local public works, such as school buildings, fire stations, sewage systems, roads and streets, city buildings, lighting systems, pumping stations and similar projects are being received daily at the Reconstruction Finance Corporation headquarters in Washington.

Hundreds of loan applications for self-liquidating local projects are also coming in. These projects are provided for under Section II of the Relief Act, for which by far the largest amount of money is appropriated—a total of one and one-half billion dollars. Loans from this fund made to local agencies are for local construction projects which will, over a period of time, have an income (not from taxes) great enough to pay back the loans. Atlanta, Georgia, for example, has applied for ten million dollars to construct a new sewage system with modern disposal facilities. The loan may be repaid by making a service charge to residents for use of the new system. In some communities, where the local government is not allowed to make such charges, non-profit corporations, as allowed in the Relief Act, are being formed by local citizens to make the loan and handle the project for the community until the loan has been repaid, when the project will be turned over to the local authorities. Loan applications for every conceivable type of project which will help local unemployment conditions and give communities needed public improvements are being handled as rapidly as possible. Typical projects being considered are public bridges, waterworks, markets for public use, low-cost housing projects, slum area reconstruction, certain local highway projects, swimming pools, playgrounds, park systems and similar local improvements.

A Few Examples of Loans Granted

Certain communities have seized upon this opportunity for reviving local business, putting money into circulation, easing unemployment and getting local public works now, financed without difficulty, while other sections are wasting time or from sheer apathy are still ignorant of the chances for local improvements. Some of the more wide-awake communities have already obtained loans, among which the following are a few typical cases:

Town or City	Amount of Loan	Purpose
Wilmette, Ill.	$580,000	Municipal waterworks
Savanna, Ill., and Sabula, Iowa	190,000	Toll bridge, Mississippi River
Roanoke Rapids, N. C.	365,000	Municipal waterworks and sewage system
Sandusky, Ohio	77,000	Water system and sludge basin
Maysville, Ky.	47,000	Filtration plant
Columbia, Ky.	29,000	Completion of water supply system
Conneaut, Ohio	200,000	Water system improvements

The short time limit provided by the Relief Act means that those communities which make first application will in all probability realize first benefits, while those who lag behind may be left out entirely. To get local projects lined up, to lay out plans and provide sites takes time. With a maximum of two years' time—much less for certain projects—it looks as though some localities will hardly be able to complete their loan plans and get consideration unless work is started immediately.

Local business men connected with the concrete construction industry should confer with local public officials with the view of listing public works projects on which R. F. C. loans can be obtained—and then help them in getting the applications started toward Washington.

EDITORIAL

Heating Coarse Aggregates in Warm Weather

ON a warm and sunny day in mid-October the editor of "Concrete" visited a street paving construction project where the contractor was required to follow the specifications by heating both the fine and the coarse aggregates.

Long piles of aggregate were heaped over a large steam pipe, for which a boiler supplied the live steam. The setting up of the heating plant, the handling and rehandling of the aggregates, the fuel consumed and the extra attendants needed, all represented extra expenditures which came out of the contractor's pocket—and which were wholly unnecessary.

As pointed out in an editorial on this page in the October issue, and in editorials and articles in other issues of "Concrete," there is no need of heating anything but the mixing water in ordinary fall and spring weather. The cost of heating water is a very small item compared with the cost of heating aggregates.

Water heated to 180 or 200 deg. F. will provide ample warmth for concrete placed during temperatures down to 15 deg. F. In colder weather the water and the sand should both be heated; but it is seldom, if ever, necessary to heat the coarse aggregate.

Too many specification writers and engineers in charge of supervision do not comprehend these simple facts. For them it is much less trouble to require all the materials to be heated than to provide for the exercise of judgment based on past experience; but for the contractor these needless and arbitrary requirements mean a dead loss.

Where Initiative and Speed Are Most Needed

DURING recent weeks many men of national prominence have urged more initiative and greater speed in the pushing of applications for R. F. C. loans for the construction of local projects of a public or semi-public character.

Public officials of many of our smaller communities seem to be holding to the erroneous belief that R. F. C. loans are intended only for large projects representing the expenditure of millions of dollars. This belief is wholly wrong, though it continues to prevail in spite of the publicity given to the stated policies of the R. F. C. An article on another page in this issue lists eight typical loans recently granted to smaller cities and towns, ranging from $29,000 to $580,000. All of these loans were made through the R. F. C.'s purchase of municipal or corporation bonds.

The fact is that if local public officials will only bestir themselves, they will find that a large part of the billion and a half dollars made available for self-liquidating projects will go to the smaller communities. Toll bridges and viaducts, waterworks improvements, sewer systems, garbage disposal plants and sewage treatment plants are among the needed public improvements for which loans have actually been granted. Mass housing, public markets, public docks and terminals, canals and tunnels are among other classes of projects for which applications for loans are pending.

Business men who understand the advantages to be gained from a stimulated construction industry can perform a distinct public service by helping local public officials in getting the loan machinery started.

Both initiative and speed are needed if this billion and a half of credit is to be translated into early employment and business improvement.

Why Intelligent Laymen Want Concrete Roads

A RECENT editorial in the Washburn (Illinois) Leader is interesting as a straight-from-the-heart expression of opinion from a layman on the utility of concrete roads for rural communities.

In discussing the concrete road program of the neighboring county of Iroquois, the editorial says:

"Iroquois County has now a total of 172 miles of concrete highway constructed by the county, in addition to the state routes. Over there they are sold on the proposition that concrete is cheaper than any other type of road, inasmuch as the state takes over the matter of maintenance cost forever.

"Most of the roads built by Iroquois County are 10-ft. strips of slab. On roads carrying heavier travel some 18-ft. slabs have been laid, and they anticipate adding more of each type annually until the entire county is provided with concrete to every farmer's door.

"Meantime, with . . . many men out of work who would be glad to have day labor at any price, we sit awaiting our own annual season of mud, with our folks marooned miles from town and unable to get out of their own gates. Perhaps it is smart, but we don't presume to know."

Here is another instance where a man in a position to know the sentiment of his community believes that the most permanent type of road construction is the most economical in the end.

PROGRESS—In a Page

Current activities in research, in matters pertaining to concrete and cement, as being carried on or completed by various organized groups.

Hold Hearings on New Building Code for Chicago

THE first public hearing on the proposed new building regulations for Chicago was held on October 19, before a city council committee.

These proposed new regulations were completed several years ago by a large committee of engineers, architects and contractors, headed by Oscar W. Rosenthal, of the O. W. Rosenthal-Cornell Company, general contractors, Chicago. As in the case of the proposed new code for New York City, great difficulty has been encountered in getting city officials to take action toward the adoption of an ordinance putting the regulations into effect.

In general, the regulations covering reinforced concrete are in close agreement with the recommendations of the American Concrete Institute.

The second hearing has been set for November 2, at which time objections to the structural engineering features of the code will be received.

Light-Weight Concrete

SEVERAL new British patents have been issued for methods designed to produce concrete of light weight.

In one method (British patent No. 368,742, by J. Y. Johnson) water-soluble acid tars, or salts thereof, are used as foaming agents in the production of a light-weight, porous concrete or gypsum plaster. The proportions and method of manufacture are specified.

Another method (British patent No. 369,241, by A. F. Berry) is described as a reinforced "gas" concrete block or slab.

A third patent (British patent No. 369,322, by W. T. Warren) describes a process that produces a light-weight concrete consisting of 1 to 4 parts of cork fragments, 1 part of cement and 4 parts of sand, with sufficient mixing water to produce a plastic consistency.

More Highway Research Abstracts

HIGHWAY Research Abstracts No. 4, dated September, 1932, is a 7-page multigraph which has been issued by the Highway Research Board of the National Research Council, 2101 Constitution Ave., Washington, D. C., as a means of bringing to the attention of highway engineers various reports and papers which have not been extensively published, but which are of distinct value to the profession. Following are the titles and authors of those of the abstracts which deal with cement or concrete:

(1) *Effect of Hot Cement in Road Paving*, by P. D. Miesenhelder, assistant chief engineer in charge of materials and tests, Indiana State Highway Commission.

(2) *Study of Shrinkage Cracking on a Concrete Road in Ohio*, by H. P. Chapman, chief engineer, and R. C. Sloane, research engineer, Ohio Highway Department.

(3) *Effect of Wheel Loads Applied to the Pavement by Six-Wheel Trucks*, by V. L. Glover, engineer of materials, Illinois Division of Highways.

(4) *Crack Survey on Concrete Pavement Near Manhattan, Kansas*, by C. H. Scholer and L. H. Koenitzer, of the Kansas State Highway Department.

Copies of Highway Research Abstracts No. 4 may be obtained on request, and copies of the original reports will be supplied if available. When copies of an original report are not available, the Highway Research Board, on request, will have copies made at cost.

Pressure Under Dams

A COMMITTEE of the American Society of Civil Engineers, acting under the chairmanship of H. de B. Parsons, 26 Beaver St., New York, has undertaken the study of hydrostatic pressure under the base of dams, including pressures within the base.

The committee requests information from all engineers who have made observations of the subject in any part of the world. Mere opinions or theoretical discussions will be of little value. In consequence, it is suggested that the information supplied should be based on actually observed data.

Information of a useful nature received by the committee will, in due time, be published for the benefit of the engineering profession, and credit will be given to those who supplied the information. Communications should be addressed to Mr. Parsons.

Proposed Federal Specification for Concrete Aggregates

THE Federal Specifications Board, U. S. Bureau of Standards, Washington, D. C., has sent out a proposed specification for aggregate for portland cement concrete to a number of representative producers and others interested in the production or use of aggregates.

Comments and criticisms are invited, and should be in the hands of the Board not later than December 1, 1932. Copies of the proposed specification now under consideration may be obtained from the Board.

A. C. I. Adopts Standard for Reinforcing Steel

THE report of Committee 503 of the American Concrete Institute, published under the title of "Specification for Supplying, Fabricating and Setting Reinforcing Steel in Ordinary Buildings," has been adopted by the institute by letter ballot as A. C. I. Standard 503-32.

This report was first published in 1930 and passed to the status of tentative standard in 1931. William F. Zabriskie, of Detroit, is chairman of the committee that developed this standard.

Co-ordination of Basic Principles of Concrete Mixtures

Strength Variations Are Discussed in Seventh Article of Series on Concrete Technology—New Equations of Strength Relations

VII—Needed Laws of Mixtures and Known Fundamentals (Continued)

By **JOSEPH A. KITTS**
Consulting Concrete Technologist, San Francisco, Calif.

THE introductory diagram of the Abrams water-cement ratio-strength law,* showing graphically some 130 values of water-cement ratio and corresponding strengths, presents the equation $S = 14{,}000/7^{w/c}$ as the specific law of strength applying to the particular series of tests, for the following concurrent fixed and variable conditions:

Fixed Conditions:

(1) Age of concrete at 28 days;
(2) A given quality of cement;
(3) A given character of aggregate;
(4) Limited maximum coarseness of grading of aggregate;
(5) Mixtures of workable plasticity or fluidity;
(6) A given condition of mixing;
(7) Standard procedure of making, curing and testing specimens; and
(8) Skilled accuracy of control of water-cement ratio.

Variable Conditions:

(1) Cement content of mixes varying from 1:15 to neat cement;
(2) Maximum size of aggregate particle in the mix varying from 14-mesh to 1½ in.
(3) Water-cement ratios varying from 0.34 to 4.0;
(4) Water contents varying from normal consistency to 2 times normal; and
(5) Grading of aggregate varying from over-sanded mix to "maximum permissible fineness modulus."

Under these fixed conditions of material and control and the widely varying conditions of cement content, size and grading of aggregate and consistency of mix, the general effect of the water-cement ratio on the strength is clearly indicated as closely approximating Abrams' equation, $S = 14{,}000/7^{w/c}$, especially for w/c varying from 0.4 to 1.00; the definite effect, however, is obscured by large variations of strength for given water-cement ratios. For example, the water-cement ratios of 0.5 and 1.0 show strengths varying from 4,400 to 6,400 and 1,500 to 2,500, respectively. A close analysis also shows that the average strength measurements for given water-cement ratios follow a curve of the form $S = A/B^{w/c}$ for w/c ratios varying from 0.4 to 1.0±, but they do not follow this form of curve for w/c greater than 1.0±. This change of the form of the curve is clearly illustrated by platting the compressive strength against c/w (instead of w/c), and platting the curve $S = 14{,}000/7^{w/c}$ therewith.

New Questions Arise

The wide variations of the strength values for given water-cement ratios brought forth questions as follows:

(1) Is the water-cement ratio the only variable affecting the strength under the fixed conditions?
(2) Has grading of the mixed aggregate no effect on the strength except as it affects the water-cement ratio for a given plasticity?
(3) Is the effect of the water-cement ratio on the strength independent of the resulting density of the concrete?
(4) Is the effect of the water-cement ratio on the strength independent of the consistency of the concrete?
(5) Is the effect of the water-cement ratio on the strength independent of the filler-voids relations?
(6) Is there large error in the compressive strength measurements?
(7) Do these variations of strength reflect inaccuracy of control technique?
(8) Is it practicable to make concrete of uniform strength with commercial materials of standard quality?

These remain moot subjects. To the last question our answer is that it is thoroughly practical to produce concrete of uniform strength, day after day, with present commercial materials and up-to-date production equipment. The subsequent chapters, reviewing concrete mixture research since 1918, and those concluding the co-ordination of known principles of mixtures, will bring together much of the available data on these questions. This review will include some researches of the strength measurements, and of extraneous conditions affecting the strength test, which bring out facts that must be appreciated in order to interpret the basic facts of mixtures.

REVIEW OF MIXTURE RESEARCH (Continued)

Effect of Mixing, Curing and Loading on Strength

The accuracy of measurements of the strength of concrete follows the law of probability and error just as do other measurements. Large minus errors are prevalent in the cylinder compression test due to practical difficulties of putting a uniform and concentric load on the specimen. Abnormal conditions of mixing, curing and testing cause wide variations in the strength measurements which are not true indices of the actual or potential strengths under normal conditions. The technique of mixture research employing bulk volume, or weight, as the basic measure of proportions of ingredients, has proved a source of large error. Errors due to these various causes have concealed, overshadowed, and often reversed the fundamental facts. The confusion resulting from these errors is illustrated by laws of strength expressed as both a power function and an exponential function of W/C, and as a linear function of C/W.

Abrams shows, in "Effect of Rate of Application of Load on Compressive Strength (measurement) of Concrete," *Proc.* Am. Soc. Test. Mats., V. 17, II, p. 364, 1917,

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*Figure 1, "Design of Concrete Mixtures," *Bulletin No.* 1 of the Structural Materials Research Laboratory, Lewis Institute.

that increasing the rate of movement of the machine head from 0.006 to 0.150 in. per minute increases the strength measurement 20 per cent for a 1:3 mix and about proportionally to the cement content for other proportions of mix.

Abrams, in "Effect of Time of Mixing on Strength and Wear of Concrete," *Proc.* Am. Con. Inst., V. 14, p. 22, 1918, shows that the strength of a given mix increases with the mixing time, as given in Table 1 for concrete aged 28 days.

TABLE 1—EFFECT OF TIME OF MIXING ON STRENGTH OF CONCRETE

Time of mixing in minutes	Relations of compressive strengths in per cent: One minute as basis	Relations of compressive strengths in per cent: Ten minutes as basis
¼	83	60
½	91	66
1	100	72
2	114	83
3	123	89
4	127	92
5	130	94
7	133	96
10	138	100

Ten minutes' mixing of a given concrete increases the strength 38 per cent over that for one minute. In other words, the strength for one minute mixing is about three-fourths of that for ten minutes. Elapsed time, up to two or more hours, between mixing and molding, further increases the strength. These are sources of considerable error.

Abrams, in "Effect of Curing Condition on Wear and Strength of Concrete," *Bul. 2,* S. M. R. L., 1919, shows the relation of strengths at 120 days age of specimens of a given mix cured as follows:

(1) Damp sand 120 days, tested damp,
(2) Damp sand 21 days, air of laboratory 99 days,
(3) Damp sand 3 days, air of laboratory 117 days,
(4) Air of laboratory 120 days.

The graph of the strength-curing relations, for average consistency mix, shows the effects of moist-sand and room-dry storage as in Table 2.

TABLE 2—EFFECT OF MOIST AND DRY CURING ON STRENGTH

Damp-sand storage—First No. of days	Room-dry-air storage—Remainder of days	Compressive strength at 120 days	Percentage relations of strength	
0	120	1760	100	43
3	117	2120	120	52
10	110	3250	185	79
21	99	3860	219	94
30	90	4100	233	100
120	0	4460	253	109

The strength of the concrete cured in room-dry-air storage for 120 days is 40 per cent of that cured in damp-sand for 120 days; in other words, the damp-sand cured concrete is 2.5 times as strong at 120 days as the room-dry-air cured concrete. The potential strength of the concrete under standard curing conditions was reduced 60 per cent due to lack of essential moisture. The importance of the initial moist curing is shown clearly by 20 per cent increase for the first three days of damp-sand curing and only 9 per cent increase for the final 90 days in damp sand. This practical difficulty of initial moist curing of specimens is a source of large error in the measure of the normal strength.

The hardening or strengthening of concrete is due to chemical reaction between the cement and water. When no uncombined water is present there is no increase of strength. Temperature is also important, since the speed of chemical reaction is approximately as the sixth power of the absolute temperature.

Bulletin No. 81, Engineering Experiment Station, University of Illinois, shows the effect of curing temperature on the compressive test of concrete at various ages as given in Table 3.

TABLE 3—EFFECT OF TEMPERATURE OF CURING ON STRENGTH

Mean temperature of moist curing room, deg.	Pct. of strength at 28 days and 70 deg. F.: 3 days Age	7 days Age	14 days Age	28 days Age
30	15	25	42	56
50	25	40	63	82
70 (Std.)	35	50	76	100
90	40	60	87	110

The foregoing sources of error in the compression measurement were appreciated in the tests reported in *Bulletin No. 1.* However, these causes of error are not wholly unavoidable and, while the errors may be small for any one cause, they are sometimes accumulative for the several causes.

Errors in Compression Measurement

Harrison F. Gonnerman shows sources of large error in the compression measurement (which were not thoroughly known at the time of the tests reported in *Bulletin No. 1*) in "Effect of End Condition of Cylinders on Compressive Strength (measurement) of Concrete," *Bul. 14,* S. M. R. L., Lewis Institute, 1925, also in V. 24, II, *Proc.* Am. Soc. Test. Mats., 1924. Compression tests were made at 7 and 28 days, 3 months and 1 year on about 3,000 6 by 12-in. concrete cylinders in a study of the effects of the following conditions of tests in comparison with results obtained by the standard method under experimental laboratory precision:

(a) Position of spherical bearing block;
(b) Deflection of table of testing machine;
(c) Material used for capping;
(d) Condition of capping;
(e) Molding with uneven base and cover plates;
(f) Inclination of axis, and top surface.

The pertinent conclusions from the tests are:

1. An error of ½ in., in centering in the compression machine, gave strength measures about 90 per cent of that for standard accuracy of setting.

2. Cylinders made and capped by the standard method, tested with a ½-in. segment (circular segment of ½-in. mid-ordinate) of the cap removed, gave strength ratios slightly less than 100 per cent. With a 1-in. segment removed the strength-ratios were 100 per cent for 1:7 concrete, about 95 for 1:5 and 90 for 1:3½ concrete. With a 2-in. segment removed the strength-ratios were 90, 80 and 65 for the three concretes.

3. Cylinders with plane parallel ends but with axes inclined ½ in. in 12 in. gave about 92 per cent of the standard test.

4. Cylinders with the top surface inclined ½ in. in 6 in. tested about 95 per cent of the standard test.

5. Cylinders molded with machined cast-iron plates so as to give convex ends showed pronounced reductions of the strength measurement for very small amounts of convexity, as indicated in Table 4.

6. The most important conclusion from these tests is that great care and skill must be exercised when preparing and placing cylin-

ders for test in order to secure ends which are true planes perpendicular to the axis of the cylinder and to obtain a uniform and concentric load. Minute defects in the caps, difficult to avoid, are obviously the causes of large minus errors, and it is questionable whether the American standard compression cylinder is the most practical and most logical form of compression specimen.

These errors due to faulty bearing were not fully evaluated at the time of the tests reported in *Bulletin No.* 1.

It is obvious that the answer to Question 6 (preceding) is that there are causes of large error in the compressive strength measurement, itself, and in the measure of the normal or potential strength of concrete. This has been one of the difficulties of arriving at the basic facts in concrete research.

TABLE 4—EFFECT OF CONVEXITY OF BEARING ON STRENGTH-TEST

Mix proportions	Convexity of cylinder ends, inches 0.00	0.01	0.05
	Strength measurement, per cent		
1:7	100	83	57
1:5	100	79	54
1:3½	100	68	40
1:2	100	62	38

Other sources of error will be indicated from time to time in subsequent chapters reviewing concrete research.

Effect of Age on Strength

While the strength of a concrete mixture at 28 days is the usual criterion of quality, practical requirements (of removing shores, stripping forms, and early and final loading of the structure) demand values of strength at ages from 1 to 100 or more days.

Abrams has shown, in "Effect of Age on the Strength of Concrete," *Proc.* A. S. T. M., Vol. XVIII, Part II, 1918, that the age-strength graph is practically a straight line when strength is platted to natural scale and age to logarithmic scale. His equation of this relation is—

$$S = m \log a + b \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

in which S is the strength at a given age a of moist curing, and m and b are constants for a given condition of mix.

The equation is shown by Abrams as practically true for normal portland and some other cements, and for ages from 7 days to 9 years, but he particularly calls attention to the fact that it does not give the proper relation below about 7 days, as can be seen by taking $a = 0$.

The Abrams equation of strength with age is sufficiently accurate for ages from 7 to 100 or more days and the constants are readily determined from two established values of age and corresponding strength.

New Equations of Strength

The concrete technologist is called upon to produce concrete of any practicable strength at any age from 24 hours, or less, to 100 days, or more. The author has determined the equation of strength for any age from 0 to 100 days as—

$$S = m \log \left(\frac{a}{b} + 1 \right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24)$$

in which m and b are constants for a given condition of mix. This equation is quite accurate from 100 days, or more, down to 0 age, where $S = 0$, but the constants are not as readily determined as in the Abrams equation.

The approximate relation of 7-day to 28-day compressive strength of concrete was determined by the U. S. Bureau of Standards about 1925. The "Bureau of Standards Formula" is—

$$S_{28} = S_7 + 30\sqrt{S_7} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (25)$$

in which S_7 and S_{28} are the compressive strengths of the same concrete at the ages of 7 and 28 days, respectively.

Willis A. Slater gives very extensive data on this formula in "Relation of 7-Day to 28-Day Compressive Strength of Mortar and Concrete," *Proc.* Am. Concrete Inst., Vol. XXII, 1926; and discussions by Fred. E. Giesecke and Edw. E. Bauer give additional data of agreement. Bauer also presents, in his discussion, an equation of tensile strength—

$$T_{28} = T_7 + 8\sqrt{T_7} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

in which T_7 and T_{28} are the tensile strengths of the same concrete at ages of 7 and 28 days, respectively.

It is the author's conclusion, from considerable application of these equations, that the general relation is expressed by—

$$S_{28} = S_7 + k(S_7)^n \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (27)$$

or

$$\log(S_{28} - S_7) = n \log S_7 + \log k \quad . \quad . \quad (27a)$$

The Bureau of Standards formula is very nearly correct, for normal portland cement and aggregates of standard quality and standard conditions of curing and testing, and has considerable practical value. The 28-day strength predicted from the 7-day strength is generally as reliable as the 28-day test. By co-ordination of Abram's equation of strength with age (Eq. 23) with the bureau's formula (Eq. 25), it is possible to predict, with practical accuracy, the strength at any age (over 7 days) from the strength at any other age of 7 days or more. By co-ordination of the formula with the author's equation (Eq. 24) it is practicable to predict the strength at any age in reasonable relation to that of the given age. Then, by noting the W/C ratio, we have an index of the proper W/C for a given strength at any age.

The strength of a given concrete with age may follow the equation—

$$S = 3{,}485 \log \left(\frac{a}{8} + 1 \right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (24a)$$

and it is therefore evident that error in elapsed time between molding and testing is a source of error in the measure of the potential strength at a given age.

Essentials in Determination of Fundamentals

This phase of concrete research, covering particularly the causes of error in the compressive strength measurement, shows the difficulties of arriving at the fundamental facts and laws of mixtures where the compressive strength is the criterion. It is evident that, in order to determine a definite law in terms of the compressive strength, the following rules must be observed.

(1) Appreciate the sources of error and take measures to eliminate them;
(2) Employ average values of a number of tests made by different individuals on different days;
(3) Determine the probable error of the average values;
(4) Increase the number of tests, if necessary, to reduce the probable error of the average to a reasonable figure;
(5) Make thorough graphical analyses, employing rectangular, log-log, and semi-log co-ordinate paper;
(6) Determine general equation or equations fitting most closely the graph of the test results;
(7) Determine the most probable values of the equation constants by the method of least squares.

Exposition of the laws of cause and effect relative to concrete mixtures requires a special development of empirical equations, now in its infancy.

(To Be Continued)

Dispersed Carbon Black—New Pigment for Concrete

By MILES N. CLAIR
Vice-President, The Thompson & Lichtner Co., Inc., Boston, Mass.

Highway Concrete and Cast Stone Work Are Two Important Fields of Use — Adequate Coloring Without Reduced Strength—Workability Improved—Cast Stone in Black Marble Effects

CARBON black, produced by the burning of natural gas, has been widely used as a filler and as a pigment. If this product, as used in the finest quality printing inks, is carefully dispersed in water by a special process, the carbon black is tremendously improved in pigmenting value.

Experiments made for Godfrey L. Cabot, Inc., of Boston, Mass., producers of this type of carbon black, show that a true black concrete can be obtained with such water-dispersed black that is far superior in pigmenting value to any effect obtainable with other pigments. It was found that 3 per cent of this carbon black in terms of weight of the cement produces a darker and more "live" shade than 10 per cent of other pigments, and without reduction in the compressive strength of the concrete.

The fact that there is no deleterious effect on the strength of the concrete is of great importance, as heretofore the introduction of pigments almost invariably caused a substantial reduction in compressive strength.

Compressive Strength, Workability

Compression tests made by The Thompson & Lichtner Co., Inc., of Boston, on specimens with various percentages of dispersed carbon black gave results as follows:

Per Cent of Dry Pigment, Based on Weight of Cement	Comparative Compressive Strength, Per Cent
0	100
2	97
3	99
5	87
10	70

The color obtained with 5 per cent of dispersed carbon black is a true black, and there is little gained by the use of larger percentages. The percentages of black in excess of 5 per cent affect the consistency; but below this value there is only a slight effect on consistency, but a decided improvement in the workability. The pigment acts like some admixtures, or like additional cement, in making the mixture "buttery" or rich, and thus reduces the tendency to segregate.

Dispersed carbon black has been used in cast stone to produce, for the first time, a true black similar to that of natural black marble. The base course of the facade of the Whitehead Metal Products Co. building in Cambridge, Mass., is a black terrazzo pigmented with the carbon black here described. A real black was desired here to fit in with the black and metal color architectural scheme of this structure, which has an entire front of cast aluminum.

For Center Lanes of Highway Concrete

Probably the most unusual application of this dispersed carbon black has been for colored concrete roads. In Massachusetts, on the Avon-Brockton road, there was laid in April, 1931, about a quarter of a mile of black concrete for the center lane of a three-lane road. Less than 3 per cent of dry pigment in terms of the weight of the cement was used. The dispersed black was furnished in the form of a paste containing 75 per cent of water, which mixed instantly with the concrete, producing a mixture more "buttery" and fat-appearing than the uncolored concrete. No difficulty was encountered in finishing and producing a clean job.

The road has the appearance of the typical Massachusetts dual type road, with the better riding qualities of

Placing black portland cement concrete on Massachusetts highway

Massachusetts road with black portland cement concrete in inner lane black concrete for the black portion, previously made of bituminous macadam. A recent examination of the road, after more than a year of use, shows no signs of wear, crazing or cracking. The color of the center strip of black portland cement concrete is apparently the same as when first laid, and it stands out in strong contrast to the two uncolored side strips.

The interest in the use of color for concrete roads for purposes other than traffic control is seen from the fact that recently the top course of a short length of a two-course road in Long Island was laid with dispersed carbon black as a pigment, for the purpose of coloring the road a pleasing gray to blend in with the landscape and to relieve eye strain.

Square Deal for Home Owner Is Purpose of Campaign

"A Square Deal for the Home" is the campaign slogan under which the San Antonio *Express* and the San Antonio *Evening News*, Frank G. Huntress, president, are supporting the cause of the individual home-owner in behalf of home building, home ownership and home making with the expressed belief that the home is the unmistakable foundation upon which to reconstruct the business, industry, commerce and social life of America.

The campaign was started on September 4 by the organization of the National Association of Home Founders, which has for its purpose the organization of public sentiment in favor of home ownership and the return of the home to its proper place of first importance in American life.

The platform of the association, sponsored by the newspapers, includes lower interest rates on home loans; cheaper financing; standard, guaranteed construction at lower cost; fair appraisals on real estate for home building; honest advertising and publicity; national competitive sales promotion; lower taxes on homes; and the return of the home to a place of first importance, socially, economically and commercially.

The actual newspaper campaign was launched Sunday, September 18, with a teaser campaign extending over a week, supported by editorial news and advertising, with supporting letters to business concerns and civic leaders. Following this came a membership campaign in which the readers of the papers were asked to join the association and pledge it their support.

~ PERSONALS ~

H. J. Lyons, formerly with the Chicago district office of the Portland Cement Association, has moved to Mason City, Iowa, where he will serve as field engineer in the three northern tiers of Iowa counties, for the Des Moines district office of the association.

W. G. Cobb, who has been with the New York office of the Portland Cement Association for some years, has severed his connections with the association to engage in the promotion and sale of concrete waterproofing materials for the Tricosal Products Company, Inc., 11 West 42nd Street, New York.

Coming Conventions

December 1-2—Highway Research Board, twelfth annual meeting, National Academy of Sciences Building, Washington, D. C.

January 16-18—National Crushed Stone Association, sixteenth annual convention. Book-Cadillac Hotel, Detroit, Mich.

January 16-20—American Road Builders Association, annual convention and road show. Statler and Fort Shelby hotels, and Municipal airport.

January 16-23—Highway and Building Congress. First annual meeting. Detroit, Mich.

January 17-18—National Sand and Gravel Association, seventeenth annual convention. Book-Cadillac Hotel, Detroit, Mich.

January 18—National Ready-Mixed Concrete Association, third annual convention. Book-Cadillac Hotel, Detroit, Mich.

February 21-24—American Concrete Institute, twenty-ninth annual convention. Palmer House, Chicago, Ill.

June 26-30—American Society for Testing Materials, annual meeting. Stevens Hotel, Chicago, Ill.

Organize National Association of Engineers

The formation of a new national society of professional engineers to be known as the National Association of Engineers, designed to include in its membership the rank and file of the engineering profession throughout the United States, estimated to number approximately 100,000 electrical, chemical, civil, mechanical and other classifications, has been announced by R. M. Sanders, a production engineer, New York City, who is temporary chairman of the movement. The primary purpose of the new organization is declared to be the raising of the engineer in public estimation, and to secure for him recognition in the minds of the laymen similar to that of the members of other professions.

The new National Association of Engineers does not conflict in any way with the older national engineering bodies, but aims to supplement their work from the human rather than the scientific angle. Headquarters of the new organization are in Room 202, at 103 Park Avenue, New York City.

Control of Ready-Mixed Concrete —A Correction

In the article on "Simplified Control of Ready-Mixed Concrete," by D. V. Terrell, in the October issue of CONCRETE, a printing error appears in the two formulas in the illustrative problem in the first column on page 9. The first bracket, in each case, was erroneously placed after the minus sign, whereas it should have been at the beginning of the formula.

Producers of Ready-Mixed Concrete Must Convince the User

Architects, Engineers, Contractors, Owners, All Have Their Own Viewpoints — Proof of Ability to Meet Their Demands Is Best Sales Argument—Some of Special Qualities Required

READY-MIXED concrete produced with a properly designed and carefully operated plant can and should possess a high degree of uniformity as well as quality. It is these two attributes—uniformity and quality—which are essential to clean surfaces, freedom from segregation, honeycombing, and kindred defects so disfiguring to an architect's otherwise pleasing design. True, the form work must be well built, the placing must be properly done. Good, uniform concrete can be spoiled even after it reaches the job. The mere fact that concrete is mixed and delivered to the job with the very best of equipment is not in itself proof that it is good concrete, accurately proportioned, unvarying in the quality and characteristics of its aggregates. Nevertheless, well designed equipment should be able to equal at all times, and usually to excel, the best job mixing plant in these respects.

What the Architect Is Looking For

The architect who is looking first for a pleasing final appearance will scrutinize the ready-mixed product of the local plant with this in mind. Can you satisfy him from that point of view? Can you show him that in your 1½-in. graded aggregate the ½-in. size will not predominate in one batch and the 1¼-in. size in another batch, as might occur on a job where aggregates are taken from a conical stock pile?

The next architect may attach great importance to the weathering characteristics of your concrete. Will it remain unchanged for a long time? Are your aggregates sound? Have they an established reputation for durability in your community? Can you point with becoming pride to old structures in which the same aggregates were used? Is your source of supply constant? Is the job-mixed concrete in your locality likely to receive its supply of aggregates from equally constant sources, or might it receive them from a variety of sources? These are some of the things the architect looks for. What does he find in your case?

Again This Question of Density

Or, perhaps your architect is interested in the prevention of efflorescence, or incrustation, or other kindred, unsightly blemishes, which usually are associated with porous, pervious concrete. Can you convince him that your rigid and accurate control of a concrete designed for density is superior to that of a job-mixed product?

The architect is undoubtedly interested in quality; but appearance, durability and uniformity of surface are not unrelated to quality; and by quality I mean those physical qualities which are so generally the basis of specifications, such as strength, density, impermeability.

The engineer, on the other hand, while he may have an eye for beauty, is likely to focus his attention on the more utilitarian characteristics of your product. He designs on the basis of strength. His concrete must attain the design strength or his structure is unsafe. He is fundamentally a safety engineer. All engineers are safety engineers. They design for safety and they must construct for safety. It may be safety against static loads, impact loads, hydraulic pressure, abrasion, chemical action, or what not; but his primary concern is that the materials used shall be safe for the service to which they are to be put. He must assure himself of several things. He knows, or should know, that his concrete must not be mixed with more than a certain amount of water. He knows that once the water ratio is fixed there may be considerable variation in the proportions of both fine and coarse aggregate without sacrifice of strength. He knows, too, that unless his leaner concretes contain a certain minimum amount of cement per cubic yard they will be porous and but ill adapted to withstand either frost action or percolating or disintegrating waters. He knows that it is the quality of the concrete after it is in place in the forms, and not as it reaches the job, that counts. He knows that segregation may be aggravated or even caused by the type of delivery or transporting system used. He is very fussy about such matters as segregation, time of mixing, and water content and workability.

Insistence on Rigid Control

The engineer is interested in these things and insists upon each of them being under rigid control because they have a marked effect upon his concrete. You are equally interested because you want his business. You can only get it and keep it by establishing in him a faith in your performance.

One is not in the ready-mixed concrete business long before the engineer's insistent demand for homogeneous concrete, free from segregation, a uniform time of mixing and of water content, become a familiar refrain. He is interested in, and insists upon, many other things; but these he harps on. They represent his viewpoint.

Let us see how ready-mixed concrete looks from the contractor's point of view. The very name contractor suggests price, since a consideration or compensation is an essential

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Abstracted from paper entitled "Ready-Mixed Concrete from the Viewpoint of the Architect and the Engineer," presented before the second annual meeting of the National Ready-Mixed Concrete Association by Cloyd M. Chapman, Consulting Engineer, New York, N. Y.

to every valid contract. But to say that the contractor looks primarily at the price of your product does not mean that he can decide the relative cost of ready-mixed and job-mixed concrete by comparing your price with his cost for materials plus his cost of labor for mixing. The wide-awake contractor knows well enough that even so apparently remote an expense as the deterioration of his equipment while in the storage yard between jobs is just as truly an item of cost of his job-mixed concrete as is the wage of the mixer foreman. He knows that if he can complete his job in a fewer number of days by using ready-mixed concrete he is cutting down his overhead, and that every dollar so saved should be deducted from your bill if he would arrive at the true cost.

What the Contractor Must Have

It is not alone the purely cost items that receive the scrutiny of the average contractor, although almost all of his concern may be traced back to a money basis. For example, he wants workability because it facilitates placing, takes less labor and, therefore, reduces costs. He wants reliable and steady delivery because interruptions and delays throw his placing crew out of work, and thereby increase cost. He wants strict compliance with specifications because rejections cause delays and almost inevitably increase the cost.

He may rely entirely upon the architect or the engineer to take all the necessary precautions and attend to all inspections and tests to insure suitable quality, but he knows full well that if any of his concrete, whether purchased ready-mixed or mixed on the job, is rejected or condemned after placing, he is bound to be a loser. In the one case he is the sole loser, and in the other case, although the ready-mixed concrete manufacturer is the chief loser, the contractor never gets out whole after a rejection or condemnation. He, therefore, is vitally interested in your ability to fulfill the specifications and your reputation for doing so.

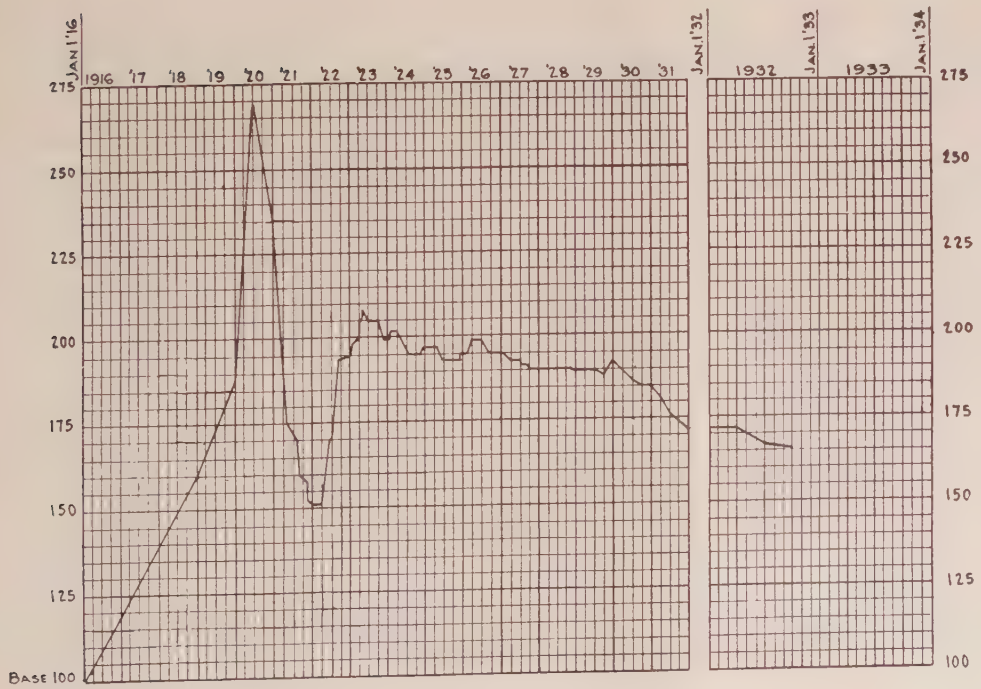
Convincing the Owner

The owner, too, has a viewpoint, or several of them. He is interested in all of the things that interest the architect, the engineer and the contractor. He may depend upon the architect for a pleasing appearance, upon the engineer for quality and safety, and upon the contractor for low cost; but as the one who finally pays the bill he is the judge of which of these three items shall be emphasized. If his greatest desire is for beauty you will have to appeal to his esthetic sense and prove to him the uniformity of your product, or perhaps its durability or weathering properties. If his first thought is for quality, strength, performance, safety and low maintenance cost, then you must have the evidence that will satisfy him on that score. Or, if he has the low cost complex you need to have as accurate data on the cost of job-mixed concrete as you have on the price at which you will furnish it.

I do not mean to imply that one must travel three different roads to reach beauty, quality and low cost. A structure need not be ugly because it is cheap, and quality is a matter of selection and design rather than cost.

Aberthaw Index of Cost of Building

(Published in the issues of February, May, August and November)



Cost of building construction, estimated for the quarter ending September 30, shows a decline of a single point to the index value of 166, in the Aberthaw Index of Cost of Building. This index value is equal to $1.74 per sq. ft. of floor area for the 7-story reinforced concrete industrial building used as the basis for the estimate.

This minor decline is due to a slight reduction in cost of materials, a reduction which was offset in part by the July and August advances in the price of portland cement.

The diagram shows that the cost curve, which started its decline in the first quarter of 1930, now is inclined to flatten out.

HOW TO DO IT

✦ Questions and Answers ✦
Consultation and Comment

A department devoted to the solution of problems encountered in concrete work. Readers are welcome to add to or improve upon the suggestions printed and to submit their views for possible publication.

Concrete Tank for Storage of Fuel Oil

We have a customer who wishes to provide a fuel oil storage capacity of 60,000 gallons by means of a reinforced concrete tank. Please let us know what special precautions should be taken in making and placing the concrete, and whether any special form of waterproofing is necessary.—E. A. C., Stoneham, Mass.

So far as the concrete itself is concerned, the mixing proportions (including the water-cement ratio) should be selected with the view of obtaining the greatest possible density. This will mean well graded aggregates, using preferably two sizes of coarse aggregate. It might be well, for instance, to use a well graded sand of high quality, a small, coarse aggregate of about pea-gravel size, and then a coarser size, up to ¾ in. or thereabouts.

The water content should not exceed 6 gallons of water to the sack of cement, this quantity of water including the moisture in the aggregate. Less water per sack of cement should be used if possible.

If feasible, the concrete should be placed under the influence of a vibrating tool. There is no question that a high-frequency vibrator will add greatly to the density of the finished concrete.

In regard to waterproof linings, this subject is covered in boiled-down but very practical form, on page 39 of the February (1932) issue of CONCRETE, in a short article headed "Industrial Liquids Injurious to Concrete; Protective Coatings." You will see that fuel oils (mineral oils) are classed as liquids that are harmless to concrete, provided the oil does not contain sulphur that is liable to form hydrogen sulphide.

This precaution against the possible effect of hydrogen sulphide suggests that the safest course is to provide an inside lining or coating of acid-resisting asphalt, a coating of paraffin wax, or mixtures of pitch and tar, as recommended in that article.

Manufacturing Monuments of Cast Stone

We are considering the manufacture of monuments and mausoleums of cast stone, in the belief that a market for these products can be developed here. Is there any likelihood, in your opinion, that serious opposition might be encountered through local labor unions, or through regulations forbidding the use of cast stone for this purpose.—P. B. J., Raleigh, N. C.

The question you raise was answered rather thoroughly in an article headed "Making Monuments and Mausoleums in Cast Stone," printed on page 34 of the April (1932) issue of CONCRETE. This article sets forth the opinion of J. W. Warren, of the Southern Cement Products Company, Knoxville, Tenn.

Mr. Warren states that he has no knowledge of any cases where regulations forbid the use of cast stone monuments, but that some cemetery companies and associations prohibit the use of anything but natural granite or marble. This attitude, he asserts, is prompted by bad work in cast stone in the past.

Probably the greatest obstacle to overcome is the hesitancy about taking a departure away from natural stone. The greatest danger to an established business is the possibility of the sale of inferior products by an inexperienced or incompetent manufacturer who may be attracted by what appears to him to be "easy" profits. A few bad pieces of work by a competitor of this type will kill the industry in the entire community.

The article mentioned above also contains some useful information on materials, mixtures and finishes.

Railway Shipment of Bulk Cement

In an editorial in CONCRETE, *printed several months ago, reference was made to the introduction of railway hopper cars for shipping bulk cement. Please tell me which of the railroads have inaugurated this service.—R. J. C., Columbus, Ohio.*

Railway companies which have introduced the use of hopper cars equipped for shipping and unloading bulk cement include the Lehigh Valley, the Baltimore & Ohio, the Pennsylvania, the Lehigh & New England, the Reading, the Delaware, Lackawanna & Western, and the Jersey Central. It is quite probable that additional railroads have, by this time, inaugurated this service.

Another railway car, of the tank type, designed for the shipment of bulk cement and similar materials, has been introduced by a large car manufacturer. This car is available through leasing. It is equipped with motors and other self-unloading equipment.

Light Reflection Value of Concrete

We are trying to obtain information on the light reflection value of concrete masonry units and monolithic concrete. Can you tell us where such information may be obtained?—E. R. J., Alton, Ill.

Several years ago the General Electric Company, Schenectady, N. Y., conducted tests of this character on concrete runways in airports. These tests were described in *The American City* magazine in the issue of October, 1929, but this articles does not disclose the reflection coefficients that were determined. The tests demonstrated, however, that medium finished concrete surfaces were the most suitable for airport runways.

The most recent information available on this subject in book form will be found in "Street Lighting Practice," by Harrison and Reed, published by the McGraw-Hill Book Company, New York.

New Books and Pamphlets

Report of Building Research Board

Report of the Building Research Board, covering the year 1931, is the title of a 158-page publication issued by the British Department of Scientific and Industrial Research. The report is obtainable from H. M. Stationery Office, Adastral House, Kingsway, London W.C. 2, England, at 3s. net.

The report contains numerous halftones, charts and tables, and it contains the results of investigations of many problems dealing with cement and concrete. Among these are reports on investigations of the lime content of cement, the effects of fineness, resistance of cements to chemical attack, studies of hydration of cement, the constituent compounds of cement, the crazing of cast stone and other concrete products, the carbonation of concrete, staining and efflorescence, concretes containing puzzolanas, effect of temperature on concrete, the action of sea-water on concrete, clinker and breeze concretes, and pumice concrete partition slabs.

New Designers' Handbook

Reinforced Concrete Designers' Handbook, by Chas. E. Reynolds. Published by Concrete Publications, Ltd., London, England. Cloth, 298 pages, 6½ by 9½ in., with 51 illustrations and 40 designing tables.

This new book presents complete data for the design of all kinds of reinforced concrete structures, and there is an extensive collection of fully worked examples to illustrate the use of the tables. A feature of the design tables is the large and clear lettering. Many short-cuts and simplified methods which have proved satisfactory in practice, and which are essential for the rapid solution of problems in design, are clearly set forth. Primarily, this book simplifies practical reinforced concrete design.

Statics of Continuous Structures

La Statique Experimentale des Constructions Continues (Experimental Statics of Continuous Structures), by P. Carot and C. Rieckhof. Published by Le Constructeur de Ciment Armé, 148 Boulevard de Magenta, Paris, France. Paper cover, 6 by 9½ in., 185 pages. Numerous line drawings. Price, 35 francs.

The method of analysis of statically indeterminate structures presented in this book involves the use of carefully designed paper models, in which the length and the moment of inertia of the different members of the frame bear the same relation to each other as in the corresponding members of the full-size structure.

Proceedings of Highway Research Board

Proceedings of the Eleventh Annual Meeting of the Highway Research Board have been issued in a volume of 443 pages by this organization, whose offices are at 2101 Constitution Ave., Washington, D. C.

The book contains numerous illustrated papers covering various branches of highway engineering and construction.

ORGANIZATIONS

American Association of State Highway Officials; W. C. Markham, Executive Secretary, 1222-24 National Press Building, Washington, D. C. Annual convention, Jan. 16-20. Detroit, Mich.

American Concrete Institute; Harvey Whipple, Secretary, 641 New Center Building, Detroit, Mich. Twenty-ninth annual convention, Feb. 21-24, Palmer House, Chicago, Ill.

American Concrete Pipe Association; M. W. Loving, Secretary, 33 West Grand Ave., Chicago.

American Road Builders' Association; Chas. Upham, Engineer-Director, National Press Building, Washington, D. C. Annual convention and road show, Jan. 16-20. Statler and Fort Shelby Hotels, and Detroit Municipal Airport.

American Society of Civil Engineers; Geo. T. Seabury, Secretary, 33 West Thirty-ninth St., New York City.

American Society for Testing Materials; C. L. Warwick, Secretary-Treasurer, 1315 Spruce St., Philadelphia, Pa. Annual meeting, June 26-30, Stevens Hotel, Chicago, Ill.

Associated General Contractors of America; E. J. Harding, Managing Director, 222 Munsey Bldg., Washington, D. C.

Building Officials Conference of America; Col. John W. Oehmann, Secretary, 1253 Lawrence St., N. E., Washington, D. C.

Cast Stone Institute; L. A. Falco, Secretary, Chapel St. and Blatchley Ave., New Haven, Conn.

Cement Institute; Luther G. McConnell, General Manager, 11 East 44th St., New York City.

Concrete Masonry Association; Jack Franklin, Secretary, 7071 Plankinton Bldg., Milwaukee, Wis.

Concrete Reinforcing Steel Institute; M. A. Beeman, Secretary, 333 North Michigan Ave., Chicago.

Engineering Institute of Canada; 2050 Mansfield St., Montreal, Quebec.

Highway Research Board; Roy W. Crum, Director, 2101 Constitution Ave., Washington, D. C. Twelfth annual meeting, Dec. 1-2. National Academy of Sciences, Washington.

Joint Committee on Standard Specifications for Concrete and Reinforced Concrete; F. R. McMillan, Secretary, 33 West Grand Ave., Chicago.

National Board of Fire Underwriters; W. E. Mallalieu, General Manager, 85 John St., New York City.

National Concrete Burial Vault Association; J. H. Stuart, Secretary-Treasurer, Bremen, Ohio.

National Crushed Stone Association; J. R. Boyd, Secretary, 1735 14th Street, N. W., Washington, D. C. Sixteenth annual convention, Jan. 16-18. Book-Cadillac Hotel, Detroit, Mich.

National Engineering Inspection Association; B. H. Witherspoon, Secretary, P. O. Box 1115, Pittsburgh, Pa.

National Fire Protection Association; Franklin H. Wentworth, Secretary, 40 Central St., Boston, Mass.

National Lime Association; Norman G. Hough, Secretary and Manager, 927 Fifteenth St., N. W., Washington, D. C.

National Ready-Mixed Concrete Association; V. P. Ahearn, Secretary, 545 Munsey Building, Washington, D. C. Third annual convention, Jan. 18. Book-Cadillac Hotel, Detroit, Mich.

National Sand and Gravel Association; V. P. Ahearn, Executive Secretary, 545 Munsey Bldg., Washington, D. C. Seventeenth annual convention, Jan. 17-18. Book-Cadillac Hotel, Detroit, Mich.

National Slag Association; H. J. Love, Secretary-Treasurer, 1449 Leader Bldg., Cleveland, Ohio.

National Terrazzo and Mosaic Association; U. F. Durner, Secretary, 815 West St. Paul Ave., Milwaukee, Wis.

Northwest Concrete Products Association; W. P. Hews, Secretary-Treasurer, Yakima, Wash.

Portland Cement Association; Edward J. Mehren, President; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

Rail Steel Bar Association; H. P. Bigler, Engineering Secretary; Builders' Bldg., 228 N. La Salle St., Chicago, Ill.

Wire Reinforcement Institute; R. D. Bradbury, Director, National Press Bldg., Washington, D. C.

Wisconsin Concrete Products Association; Jack Franklin, Secretary-Treasurer, 425 East Water St., Milwaukee, Wis.

Asphalt-Impregnating Process Offers Sea-Water Protection

Penocrete Method of Manufacturing Alkali-Resistant Concrete Slabs and Piling — Seven Year Test Proves Value

Means of checking the destructive action of sea water are claimed to be embodied in the Penocrete process, which impregnates concrete piling and slabs with asphalt under vacuum pressure. Concrete thus treated and immersed in sea water for 7½ years is reported to have shown no disintegrating effects.

The concrete after curing is thoroughly dried in a tempering chamber, being subjected to dry air treatment for 18 to 20 hours. Increase of temperature is gradual and uniform, not exceeding 11 deg. F. per hour for 16 hours, at the end of which period it is raised to 240 deg. The latter temperature is maintained for not less than two and not over four hours, according to the Pan-Pacific Piling and Construction Co., Wilmington, Calif., owners of the patent.

The slabs are then readily moved into the main treating cylinder which has been pre-heated and dehydrated under a 26 to 28-in. vacuum, with the object of ridding the slab of free water and producing a vacuum in the voids thus created. The temperatures are not high enough to release an appreciable quantity of the combined water of crystallization.

Thoroughly dehydrated grade D asphalt, meeting a penetration test of 0.40 to 0.50 cm., is liberated into the treating chamber at approximately 250 deg. F., the vacuum being maintained throughout its introduction. When the chamber has been filled with the asphalt the vacuum is replaced by air pressure running up to 175 lb. per sq. ft., the pressure being maintained for 12 to 14 hours. The temperature then is allowed to drop down to 200 deg. F., at a rate not exceeding 11 deg. F. per hour. The slabs are then cooled gradually. A dry mix of concrete is used in the slabs or shell.

This process impregnates the concrete to a depth of 1½ to 2 in. and so thoroughly as to completely seal the pores of the concrete and to secure the asphalt to its surface so that it cannot be detached. The penetration is deep enough so that when the surface is accidentally chipped, sufficient protection remains.

Use of Filters in Construction of Water Tunnels

When the Wenzel & Henoch Construction Co. of Milwaukee, Wis., began operation on the water tunnel to connect the Swift and Ware rivers as a part of the Metropolitan Water Supply System for Greater Boston, Mass., they were faced with the problem of keeping air compressors used on the project in continuous 24-hour day operation.

The tunnel, when completed, will be 54,000 ft. long and 15 ft. in diameter. To speed operations, four vertical shafts were sunk and operations started from these points. Each of the shafts is equipped with a battery of three Sullivan double-acting, single cylinder air compressors, each with a rated capacity of 800 c.f.m.

Because of the large amount of fine dust gravel handled at each shaft, each compressor air intake was equipped with a suitable air filter. Units selected were of the Coppus-Annis dry felt type, manufactured by the Coppus Engineering Corp., Worcester, Mass., and a Type FC-8 Unit with a capacity of 880 cu. ft. was installed in a weatherproof housing on each compressor intake pipe.

The installation has been in operation for more than five months, during which time in excess of 150,000,000 cu. ft. of air has been drawn through the filters.

New Equipment and Materials

Portable Beam Testing Machine for "Lab" or Field

A portable beam testing machine said to be similar to but lighter and smaller than the type used by the U. S. Bureau of Public Roads has been developed by the Jones Superior Machine Co., Chicago.

It is said to meet all A. S. T. M. standard specifications, is made almost entirely of steel and is adaptable for laboratory or field use. The measuring device, according to the Jones company, is rugged and accurate and will not get out of adjustment.

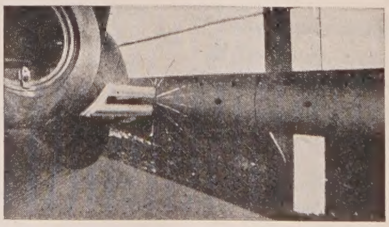
The modulus of rupture up to a maximum of 2,000 lb. is indicated direct on the micrometer dial without any further computation on a 6 by 6 in. specimen on 18-in. span and the machine is readily adjusted so the modulus of rupture up to about 1,100 lb. can be read on 8- by 8-in. 24-in. span. This latter reading requires a small computation.

The load is measured on this machine by a carefully calibrated device constructed from a special heat-treated steel.

A descriptive circular also illustrates steel beam molds.

Highway Guard Features Convex Steel Face

Convex-shaped spring steel secured to the post by means of a heavy spring bumper forms the Tuthill highway guard. The rail is placed at the proper height to receive the impact from bumpers, hub caps, wheels or running boards, and deflects the automobile back on the road with a minimum of damage.



The spring supports are bolted to the posts at their bases, for maximum strength, and steel cable may be used at the top for further safety.

This guard is a product of the Tuthill Spring Co., Chicago.

Scale Line Redesigned for Accuracy, Simplicity

Simplified design of indicating mechanism is one of the improvements incorporated in its entire redesigned line of automatic dial scales by the Kron Co., Bridgeport, Conn. Hopper, bench, track, and crane scales, as well as portable and dormant platform types, are included.

A further development which makes for easier and more accurate readings is a device for absorbing vibration in the installation which might be transmitted to the scale pointer.

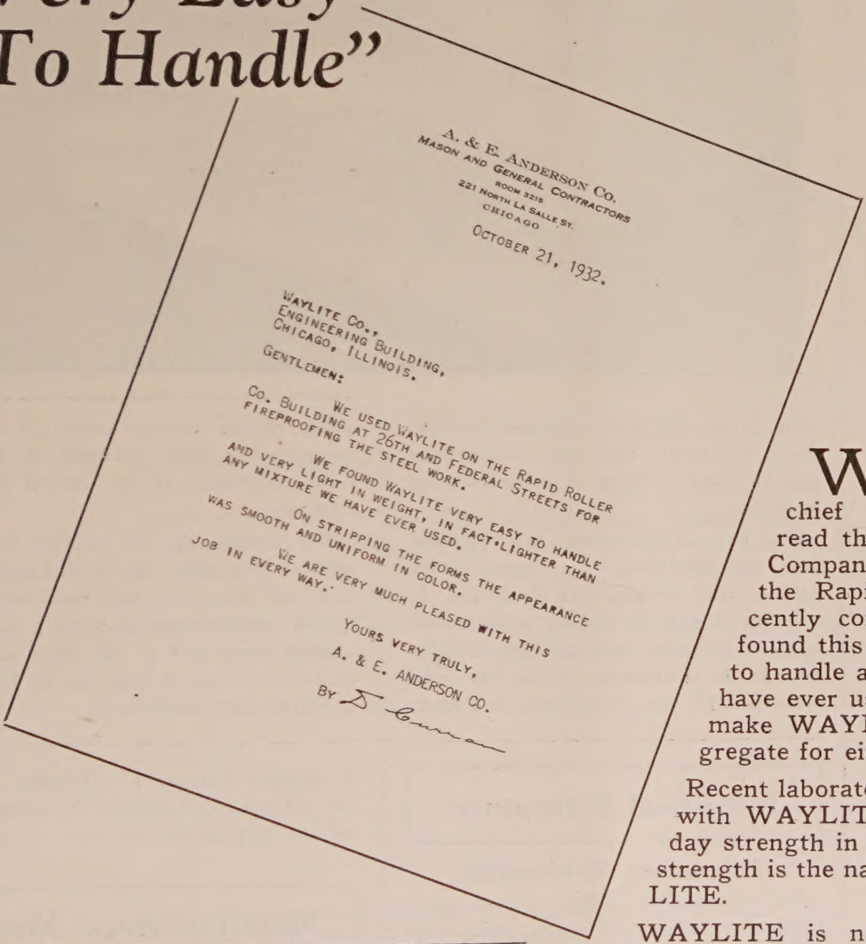
The number of bearings in the mechanism has been reduced to eight, six of which are high-grade ball bearings, especially designed for the scale application, and supported in every direction.

The entire dial head is completely sealed

WAYLITE

Lightweight Concrete Aggregate

"Very Easy To Handle"



A. & E. Anderson Co.
Mason and General Contractors
Room 3215
221 North La Salle St.
Chicago

October 21, 1932.

Waylite Co.,
Engineering Building,
Chicago, Illinois.

Gentlemen:

We used Waylite on the Rapid Roller Co. Building at 26th and Federal Streets for fireproofing the steel work.

We found Waylite very easy to handle and very light in weight, in fact lighter than any mixture we have ever used.

On stripping the forms the appearance was smooth and uniform in color.

We are very much pleased with this job in every way.

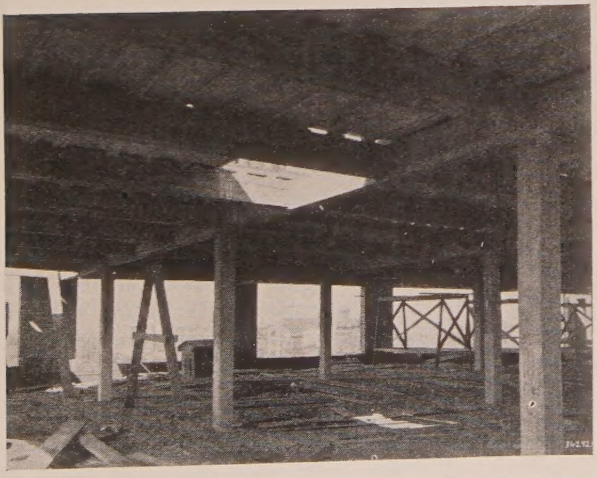
Yours very truly,
A. & E. Anderson Co.
By

WORKABILITY is one of the chief characteristics of WAYLITE—read this letter from A. & E. Anderson Company, contractors for the addition to the Rapid Roller Company building recently completed in Chicago. They have found this new light weight aggregate easy to handle and lighter than any mixture they have ever used. The perfect mixing qualities make WAYLITE the ideal light weight aggregate for either field placing or precasting.

Recent laboratory tests show that concrete made with WAYLITE acquires 80 per cent of its 28 day strength in 7 days. An aid to this high early strength is the natural cementing quality of WAYLITE.

WAYLITE is non-absorbent; flows freely, and readily adheres to any desired water-cement ratio, thereby assuring constant workability.

It is uniform in size and texture, nailable, sound deadening, chemically inert, fireproof, tough, hard and strong enough for any structural purpose. The price is as attractive as the other qualities of WAYLITE. Inquire about it.



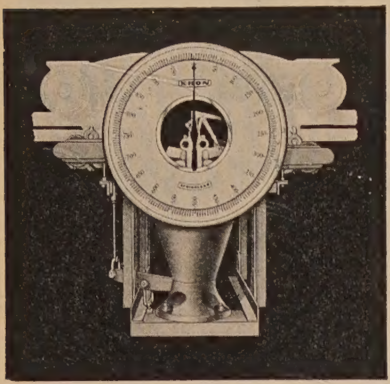
Interior of Rapid Roller Company building showing WAYLITE roof slabs (manufactured by U. S. Gypsum Co.) in place, also fireproofing of steel columns, beams and girders with WAYLITE.

Send for reports of recent tests, and see how the performance of WAYLITE makes its low price even lower. Allow us to analyze your particular problem.

Chicago Waylite Aggregate Co.

Licensed Manufacturers and Distributors in Chicago

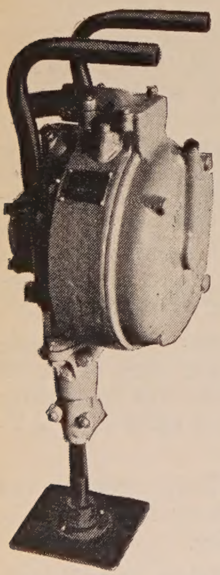
Engineering Building ~ ~ Chicago, Illinois which might affect the scale mechanism. The head is also arranged to swivel 360 deg., so that it may be turned to allow accurate reading from any direction.



Illustrated bulletins are available.

Electric Backfill Tamper Is Perfected

To its line of tools, the Electric Tamper and Equipment Co., Ludington, Mich., has recently added a newly developed electric backfill tamper.



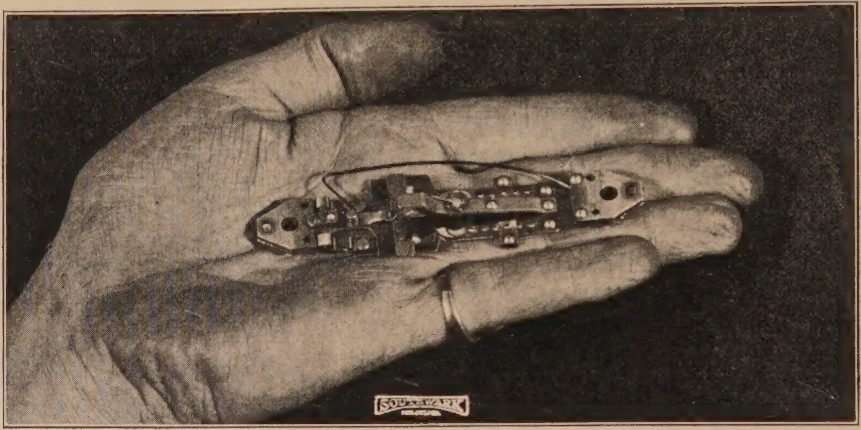
The machine incorporates in its design the basic operative principles of the Jackson hammer blow tie tamper, a railway maintenance tool that has been in extensive use on representative roads.

The Jackson electric backfill tamper is adapted to compacting fill in trenches and also behind retaining walls and abutments, handling dry and saturated material with equal facility. When fitted with the proper tool, the machine can be used for excavating clay or shale, demolishing brick pavement and vibrating concrete on bridge decks or on similar concrete construction work.

The tamper motor is wound for 110-v., 3-phase, 60-cy. A. C. If 3-phase power is available on the job site in higher voltages the manufacturers can furnish proper transformers and will supply portable power plants in two, four and eight tool capacities for jobs on which commercial power is unobtainable. The plants are light, but built to withstand severe service and are not affected by cold. Various portable electric tools can be operated by these units, which are also frequently used to furnish power for lights on night or emergency work.

Scratch Extensometer; Its Purpose, Size and Use

The Scratch extensometer, for tension-compression and shear strain recording, weighs less than an ounce, and is hardly larger than a teaspoon. It may be attached to light as well as heavy structures. Shear strain is recorded when tension-compression strain is present. Pure shear strain alone may be taken by means of a special adaptation.



The Baldwin-Southwark Corp., Philadelphia, who manufacture the Scratch extensometer, point out that with strain and the modulus of elasticity known, it is a simple matter to evaluate stress, and that the lightness of the instrument and its low price make possible the use of many in a structure for simultaneous determination of stress.

Bulletin 40 describing the unit is available upon request.

G-E Sign Lighting Control Gives Variety of Circuits

A new type of sign-lighting control that flashes, dims or brightens the lamps with a wide variety of effects—and which requires neither moving parts nor electric contacts—has been produced in the research laboratory of the General Electric Company.

The control can be applied economically to practically all incandescent-lamp signs and, when used with those which are lighted continuously, produces a more attractive effect and at the same time reduces the operating expense by from 40 to 60 per cent, it is stated.

Industrial Literature

Laboratory Publication

The evolution of weights, a development facilitating the use of burettes, and a magnetic damping device for analytical balances are some of the subjects and devices covered in the current issue, No. 4, of *The Laboratory*, published by the *Fisher Scientific Co.*, Pittsburgh, Pa.

Turner City

The 30th Annual Turner City is presented in a folder entitled *"A City Built in a Year,"* published by the *Turner Construction Co.*, Boston, Mass.

A large composite drawing represents the thirty buildings completed in 1931, the firm's thirtieth year in business.

Plywood Forms

How to obtain smooth, flawless concrete walls at lowest cost is the theme of a new, small, 6-page leaflet issued by the *Oregon-Washington Plywood Co.*, Tacoma, Wash., The advantages of Douglas fir plywood are outlined and illustrations show its use.

Manufacturers' News

Testing Machine Manufacture

A manufacturing agreement has been concluded between *Riehle Bros. Testing Machine Co.*, of Philadelphia, and the *Torrington Manufacturing Co.* whereby the machines and instruments of the former company will be built by the Torrington company at its plant in Torrington, Conn.

Riehle Bros. Testing Machine Co. will retain its corporate identity and will continue to conduct its engineering and sales.

Rex Equipment in Cleveland

The Peden Machinery Co. has been selected by the *Chain Belt Co.* to handle its complete line of construction equipment in the Cleveland, Ohio, territory.

The latter was previously taken care of by the Hibbard-Eichman-Smith Co., Inc.